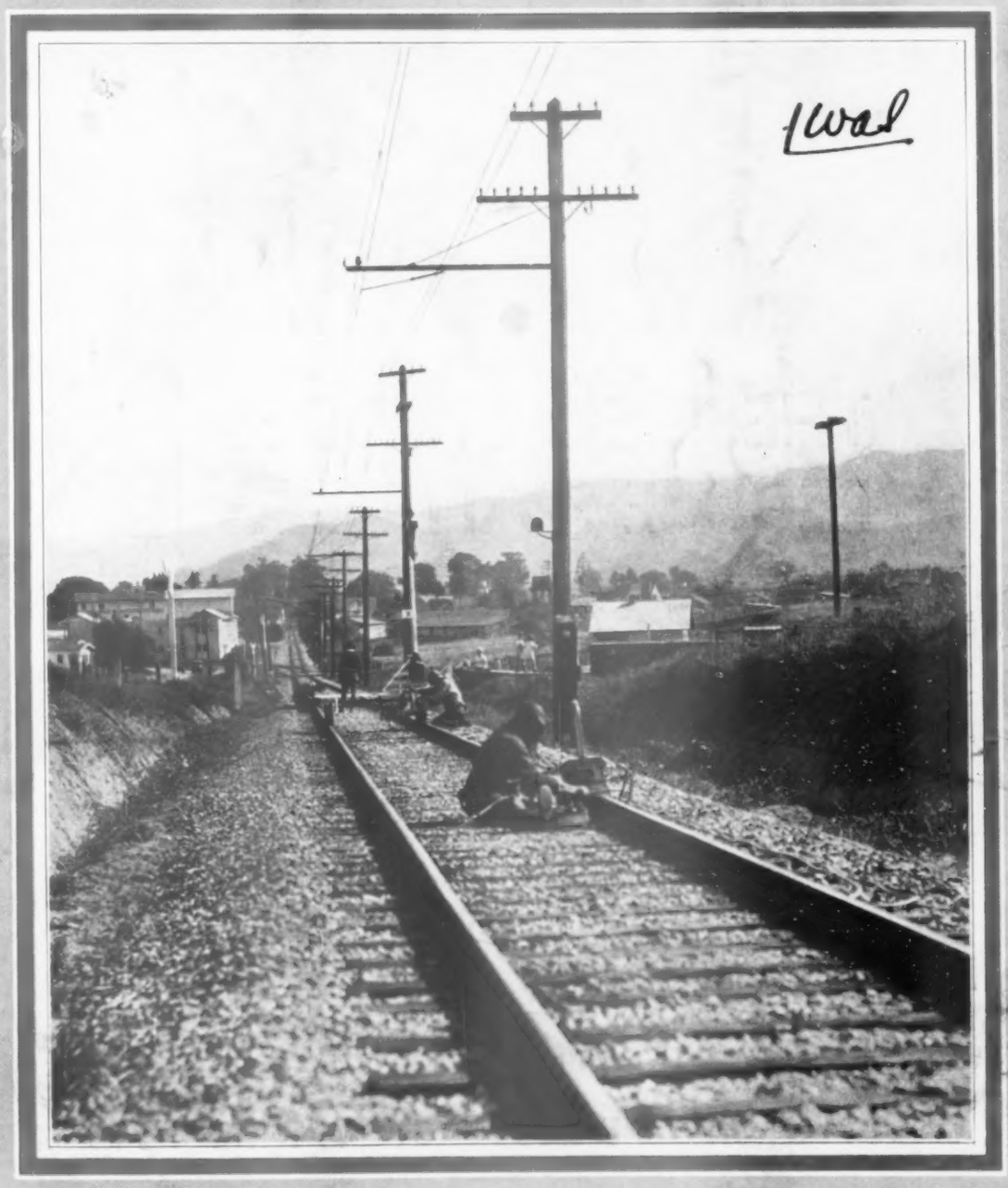
ume 18 Number 2

# The Welding Engineer

Reg. U. S. Pat. Office

Pioneer Business and Technical Journal of the Welding Industry



■ Welding Crew Building Up and Dressing Rail Ends

*(See Page 18)*

February · 1933

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# THE WELDING ENGINEER

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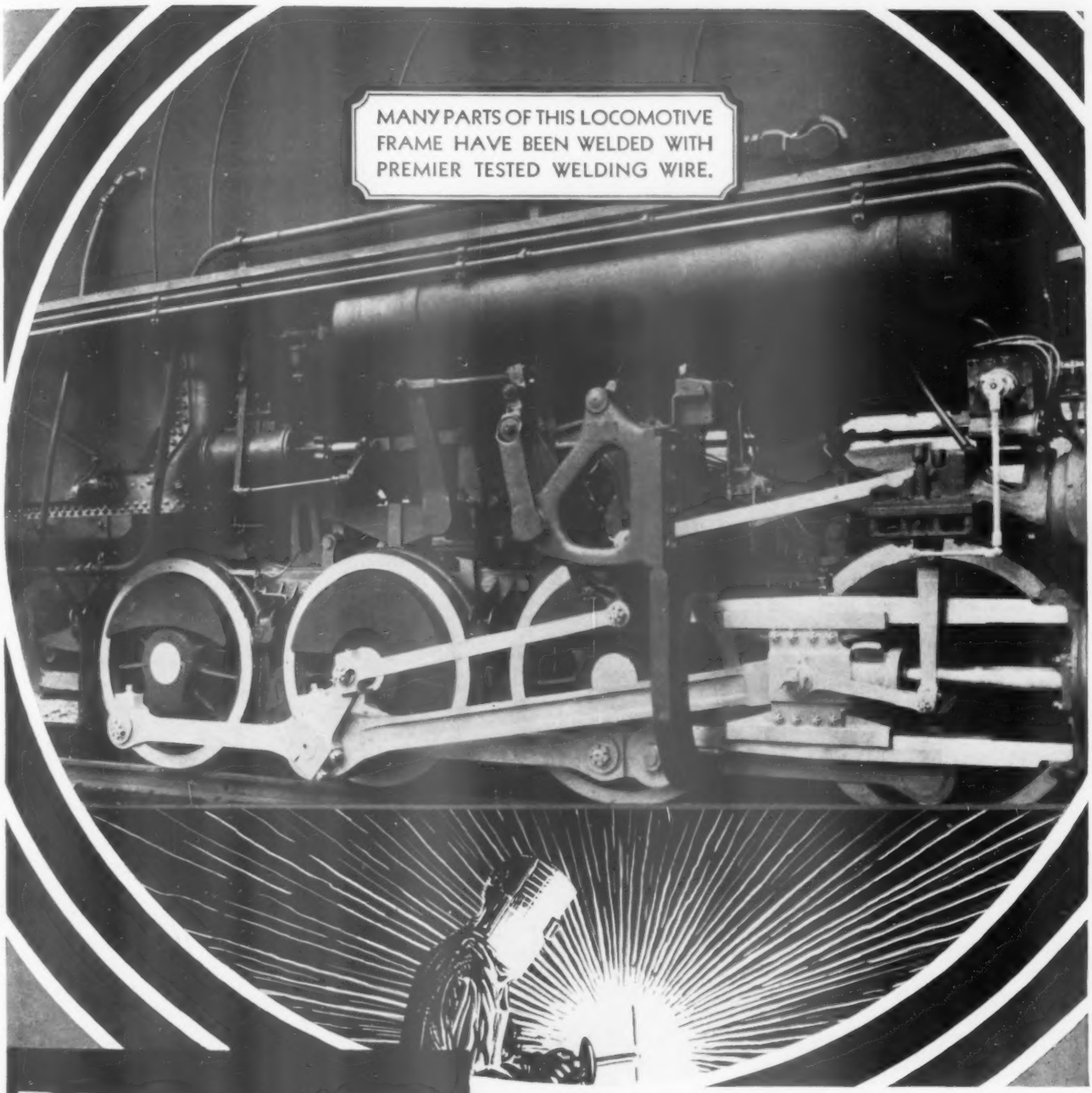


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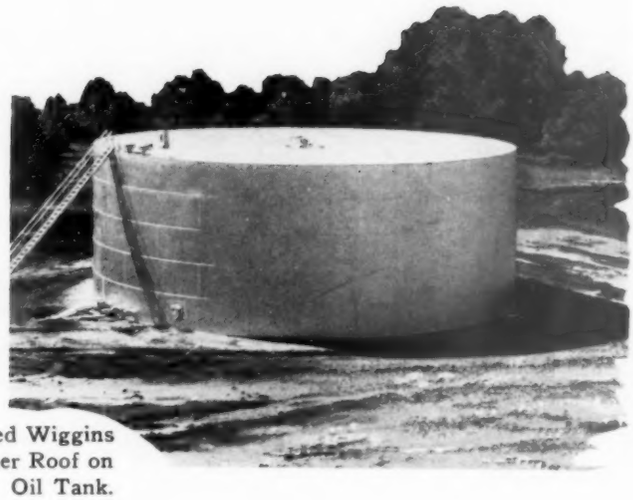
# Plate Fabrication

*as applied to*

## Tanks and Pressure Vessels



All-Welded Wiggins Breather Roof on Oil Tank.

■ By H. C. BOARDMAN
Chicago Bridge & Iron Works

Abstract of paper read October 21, 1932, before the Chicago Section of the American Welding Society.

THIS paper deals primarily with the methods developed and used by the Chicago Bridge & Iron Works in fabricating large steel electric-welded containers for the storage of liquids and gases.

During the World War, George T. Horton and E. G. Daniels, now respectively president and mechanical engineer of the company, devoted their entire time to the interests of the Submarine Boat Company of New York. Their work acquainted them with welding as applied to some phases of ship building. Being men of vision it was inevitable that they would apply welding to tank building upon their return to civil life. At first welding was used only to shop weld such parts as manhole frames, ladders, dies for the hydraulic press, and substitutes for castings.

The first field application of welding was to the fabrication of the cone roofs of the flat-bottomed oil storage tanks of the type which is familiar to all who have traveled through oil fields or visited refineries. Such roofs are practically flat, are usually made of 3/16 in. plates, and carry practically no stress, their function being to act as watersheds and sunshades. The most common of the larger sizes is approximately 120 ft. diameter. Welding made it possible to ship the plates directly from mill to site, with a consequent saving in freight, time and shop labor, eliminated bucking up rivets from the top of a movable tower on wheels called a roofing buggy, which had to be moved around as riveting progressed, and dispensed with the caulking necessary to obtain a gas tight riveted job. Automatic welding of roofs has been tried but without success.

Wiggins breather roofs, which are of essentially the same construction as cone roofs but reduce evaporation losses by acting as huge flexible diaphragms capable of passing from a sagging position through a horizontal plane to a bulging upward position, are also welded, and the welding very successfully stands up under the reversal of stresses.

The second field application was to the bottoms of storage tanks, which, like the roofs, are not designed for any calculated stress, but serve merely as impervious membranes separating ground and liquid. With riveted construction it was necessary to assemble, rivet, and test bottoms on temporary wooden supports, and then to lower them into position on the ground. Welding has made it possible to ship the plates directly from mill to site, with a consequent saving in freight, time, and shop labor, to assemble and weld the plates in position on the grade, and practically to eliminate the necessity for testing.

152,000-Cu. Ft. Welded Hortonsphere Operating at 25-Lb. Gas Pressure.

### Tar Paper Laid Under Welding Seams

The problem of painting is still troublesome. If the underside of each plate is painted before it is laid on the grade, the heat of welding burns off the paint directly beneath the bead. One method which at least partially solves the problem is to place strips of tar paper under the seams. Experiments indicate that the heat of welding will tar the plate from which the paint burns off.

It should not be inferred that the first storage-tank bottom and all others were welded without trouble and with complete success. Far otherwise. Difficulties were experienced in obtaining uniformly good welding under the widely varying field conditions of weather and personnel, in getting flat bottoms, and in determining the welding sequence which

prevents cracking of the bottom angle connecting bottom and shell. Disconcerting failures occurred, giving rise to frequently expressed doubts of the reliability of welding. Such experiences seem invariably to be the price of progress.

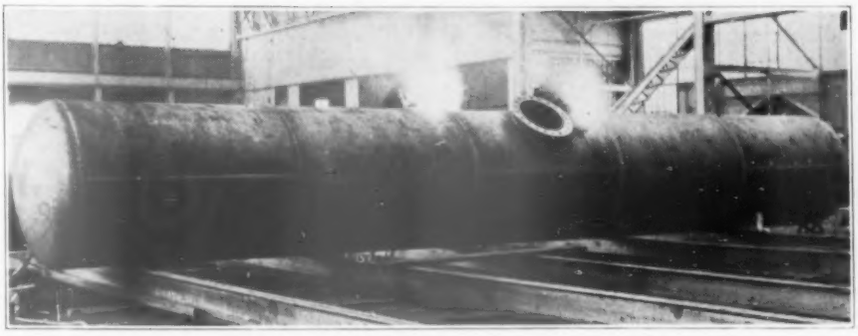
Happily, all these troubles have been largely overcome. Fairly uniform and good welding is now obtained through a well-considered set of qualification tests and careful supervision and inspection. Flat bottoms are obtained by welding the seams in such a way that the resulting shrinkage takes place freely along certain seams which are left open until all the others have been welded. Breaks in the bottom angle no longer occur, partly because the angles are now completely welded to the bottom sketches before the sketches are welded to the interior bottom plates, and partly because of the fairly recent use of shielded-arc electrodes in place of bare rods.

## Welding of Tank Shells

During the past year welding has rapidly been replacing riveting in the fabrication of storage-tank shells, necessitating the learning of a new technique for vertical surfaces. With this change, the bottom angle connecting bottom and shell, and the top angle connecting shell and roof, are unnecessary, although they are still occasionally used. The top angle is sometimes a help in rounding up the tank during erection, and in furnishing a shelf against which the edge of the roof may be welded. Shells are now invariably welded directly to the bottom unless the purchaser demands a bottom angle. A ¼-in. or 5/16-in. bead is laid on each side of the shell. It would be wasteful to use beads larger than sufficient to equal the bottom plate in tensile and bending strength. It is well to keep in mind that the amount of weld metal deposited increases as the square of the size of the fillet, while the strength increases directly as the size. This fact emphasizes the possibility of great waste in careless welded design, and of possible economies in a wise use of many small beads rather than one large one.

Two general erection methods may be used. The first is essentially the Belgian system of erecting the bottom, then the top ring and roof, then jacking up the roof and top ring, then adding the next to the top ring, and so on to the bottom ring. This sequence allows all work to be done on the ground, and requires a roof which is either self-supporting or is carried by framework connected to the top ring. The lower edge of each ring, in turn, is fitted around a system of guides tacked to the bottom plates, and the upper edge of each ring is fitted outside the lower edge of each ring above. Thus the correct circumference and shape are assured without laying out or marking the plates.

The second and more common method



**Welding a Class 2 Vessel, 5 Ft. 7 In. in Diameter and 41 Ft. 10 In. Long, for a Working Pressure of 225 Lbs.**

is essentially the same as that used in the United States for riveted tanks, the erection sequence being bottom, first (lowest) ring, second ring, third ring, and so on to the top ring, and finally, the roof framing and roof. The first (lowest) ring is assembled against guides tacked to the bottom plates, the plates are plumbed, and nuts or special devices welded on the inside at the correct lapping distance below the top edge and at a fixed distance from the bottom. The work is greatly simplified if the foundation is level.

The lower edge of the next course is set on these nuts or special seating devices, and tacked in place. Because of irregularities, the edge may not bear on all the nuts; if this is the case no effort is made to force a bearing. Along the

**All-Welded Wiggins Pontoon Roof.**

inner top edge of the second ring another row of nuts is welded at a measured distance, either from the bottom or from the row of nuts along the top edge of the first ring, and the third ring is put upon them, plumbed, and tacked. This process is continued to the top. Cumulative distortions due to edge irregularities are thus avoided.

## Preparing Vertical Seams for Tacking

The same principle is used for the vertical joints, although the application of the principle may be made in various ways. For example, nuts may be used just as described for the girth seams or a line may be drawn on the plate instead of welding on the nuts. If nuts are used, the lapping plate edges are forced together by driving pins through the nuts; if lines are used, the lapping edges may be pressed together by straddling the seam with a horseshoe-shaped frame, driving wedges between one arm and the plate, and thoroughly tacking the outer lapping edge so it will not spring outward when the horseshoe frame is removed. All vertical seams are left open until the entire ring has been assembled. Then the plates are plumbed, the circumference checked, necessary adjustments made, and the seams tacked.

All material may be handled by a roofing buggy, or by a gin pole and plate buggies riding on top of the last course laid. Except for tacking, practically all welding is done after the shell has been entirely assembled. Scaffold brackets are hung from bolts welded to the shell. Going up, the scaffold brackets are used for assembling. Going down they are used for welding. The bolts are knocked off coming down. A revolving scaffold suspended from the roof is used for welding the shell outside, if a roofing buggy has been used to handle the plates.

The method just described is by no means fully established—in fact, foremen are encouraged to try out new ideas with the hope that better methods will be developed. Some foremen believe it worth while to accurately punch, burn, or drill a few holes along the plate edges to insure accurate and rapid assembly; others favor what at present is the more popular practice of using no holes at all.

## Lap Vs. Butt Welded Joints

Lap-welded construction is now favored for storage tanks because it requires no work on the plate edges. However, especially for the larger tanks, it seems probable that butt-welded joints will grow in favor as time passes. Their use would require shearing, planing or burning of the plate edges, either at the mill, in the shop or in the field, but should simplify fitting up, eliminate the local bending stresses common to lap joints, and result in smooth shells of uniform diameter, which would, in turn, permit the use of a simpler and better seal for floating roofs.

It is well understood that evaporation of liquids whose vapor pressures at storage temperatures are less than atmos-

pheric pressure, may be reduced by providing a space in which the mixture of vapor and air above the liquid may expand and contract, or by blanketing the liquid surface. The Wiggins breather roof previously described is an expansible element, and the Wiggins pontoon roof is a blanketing element. Both are patented products.

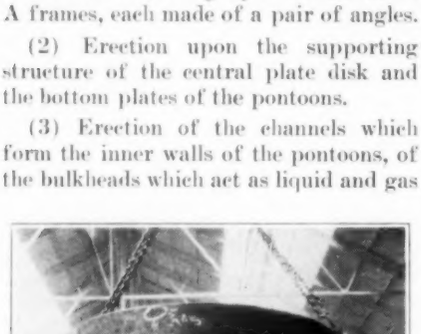
The Wiggins pontoon roof of the latest type is essentially a floating pontoon ring divided into separate sections or pontoons by bulkheads, with a plate disk closing the hole in the ring at the level of the bottom of the ring, and a flexible seal closing the gap between the ring and the shell of the tank. Nearly all the plates, which are 3/16 in. thick, are shipped directly from the mill to site, and there fabricated in position by welding. The bulkheads are fabricated in the shop. The various stages of construction are:

## Sequence of Construction of Pontoon-Type Roof

(1) Erection of the supporting structure upon which the roof rests when in its low position. This structure consists of many substantially horizontal angles and channels resting upon a number of A frames, each made of a pair of angles.

(2) Erection upon the supporting structure of the central plate disk and the bottom plates of the pontoons.

(3) Erection of the channels which form the inner walls of the pontoons, of the bulkheads which act as liquid and gas



Assembling Dished Head and Shell.

tight partitions between pontoons, of the rim plates which form the outer walls of the pontoons, and of the trusses which stiffen the pontoons.

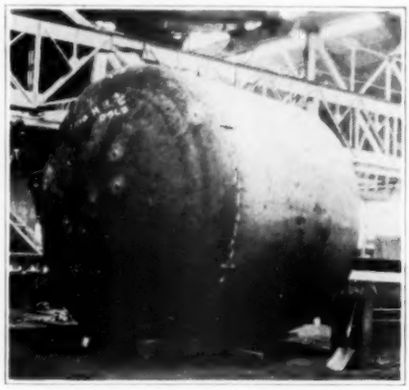
As soon as the welding of these elements has been completed the undersides of the seams of the pontoons and plate disk are thoroughly painted with penetrating oil. If there are any holes through the welds the oil will work through them and discolor the upper surface. The weld metal at leaks thus found is chipped out and new metal deposited, unless the leak is very small, in which case peening alone is sufficient. The process of testing and stopping leaks is repeated until no more leaks appear.

(4) The top pontoon plates, the seals, and all accessory equipment are installed.

(5) The welding of rims, bulkheads, and top pontoon plates is tested for tightness.

(6) The tank and roof are given a final test by filling and emptying the tank with water.

It is a real achievement to build a floating roof 120 ft. in diameter and get it absolutely liquid and gas tight. On



Head Welded to Shell.

such a roof there is approximately one mile of 3/16-in. bead. All the welding is now done with shielded-arc electrodes.

The development of shielded-arc electrodes and the adoption of the present A. S. M. E. Code permitting the fusion welding of vessels of any thickness, pressure, and size, have greatly stimulated the production of shop-welded pressure vessels. The Chicago Bridge & Iron Works builds Class 2 vessels only, which do not require X-raying, and few of which require complete stress-relieving.

For welded vessels which are to receive the A. S. M. E. stamp, only two general types of prepared joints are used—the single V, and the double V or U joints, with both of which nearly everyone is familiar. Planing the edges of plates which are to be rolled into cylinders is a simple matter; preparing the edges of plates which are to form parts of spherical surfaces is not so easy, although it can be done by chipping or burning by hand, or by shearing, planing or burning by special machines. This phase of fabrication for welded work is undeveloped, although it is under way.

## Sequence in Welding of Pressure Vessels

The successive steps in the fabrication of a shop-welded pressure vessel, are:

(1) Chipping, planing, burning, or shearing the plate edges and forming the heads.

(2) Rolling the plates. The ends usually have to be treaded or otherwise formed to the proper curvature, since the bending rolls unaided do not do it.

(3) Assembling and tacking each head to a cylinder plate, and assembling and tacking the other cylinder plates in one or more sections. Spreaders of wood or steel are installed to keep the plates round.

(4) Welding the end and intermediate sections together on a turning table. Each layer of weld metal is brushed and peened before the next layer is applied. There is a wide difference of opinion about the effectiveness of peening as a stress-relieving agent. Before the first weld layer is applied on the side opposite which welding was started, the burned metal is chipped out down to firm material. The longitudinal seams at the ends of each section are welded only to within about 6 in. of the ends to facilitate assembly to the next section.

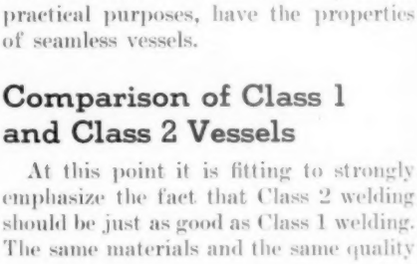
(5) The various sections are assembled, tacked and welded together, and the various accessories tacked in place and welded.

(6) The vessel is stress-relieved if necessary and then given the hammer and hydrostatic test prescribed by the A. S. M. E. Boiler Code.

The foregoing procedure permits several welders to work together with the minimum of interference with each other, and when followed by properly qualified welders results in vessels which, for all practical purposes, have the properties of seamless vessels.

## Comparison of Class 1 and Class 2 Vessels

At this point it is fitting to strongly emphasize the fact that Class 2 welding should be just as good as Class 1 welding. The same materials and the same quality



Two Types of Spreaders for Welding Cylinders.

of workmanship are used to produce both classes. Class 2 vessels are penalized 12½ per cent in weight because they are not stress-relieved by heat nor X-rayed, their thickness is limited to 1½ in., and their operating temperature is lower than for Class 1 vessels. There are conservative engineers who prefer Class 2 vessels to the corresponding lighter Class 1 vessels, who question the necessity of heat treatment in producing vessels of the highest efficiency, and who advocate stress-re-

lieving by mechanical means such as peening and testing to the calculated yield point, thus relieving the locally overstressed points by yielding in the plastic stage.

Field-welded pressure vessels are still in their infancy but probably will make rapid strides during 1933. Essentially the same methods used in the fabrication of shop welded vessels are also applicable in the field, but stress-relieving by heat and X-raying are impracticable and probably quite unnecessary. The primary result of shrinkage due to welding such large vessels is simply to slightly change the radius of curvature—not usually a serious matter. However, much must be learned before the full extent of shrinkage strains can be accurately predicted and allowed for, and before the effects of "locked-up" welding stresses on the usefulness of members under load are understood.

## Program of Ohio Welding Conference

Talks on gas and electric welding and exhibits of welding equipment and supplies, together with demonstrations of the latest developments in welding and cutting, will feature the second annual welding conference and exposition to be held at the Ohio State University, Columbus, Ohio, February 23rd and 24th, under the direction of the department of industrial engineering of the university. All sessions, exhibits and demonstrations will be held in the industrial engineering building.

The conference will be opened on the morning of February 23rd with an address by J. L. Morrill, vice-president, the Ohio State University, followed by talks by E. A. Hitchcock, dean of the college of engineering, and John Younger, chairman, the department of industrial engineering. Technical papers to be read during the morning and afternoon sessions include "Recent Developments in Electric Welding," by H. O. Westendarp, of the General Electric Co.; "Welding and Cutting—Elkonite and Carboloy," by G. N. Sieger, of the P. R. Mallory Co., and "Machine Cutting by the Oxyacetylene Process," by R. F. Helmkamp, of the Air Reduction Sales Co. In the evening, an address on "Welded Steel Homes" will be given by E. W. P. Smith, of the Lincoln Electric Co.

The Friday morning session begins at 9 a. m. with a paper on "Testing and Qualification of Oxyacetylene Welders," by W. S. Walker, of the Linde Air Products Co., followed by "Practical Experiences," by Francis Caldwell of the Jeffery Manufacturing Co., Jack Rodgers of the Marion Steam Shovel Co., and Clay Roberts of the Pennsylvania Railroad Co. In the afternoon, Arthur E. Christen, consulting engineer, will give a paper on "Pipe Welding Costs," and Nate Lord, of Tube-Turns, Inc., will speak on "Pipe Welding in Various Industries."

## Pressure Vessel Welding, Topic at Chicago Meeting

Pressure-vessel welding and qualifying welders were considered at the meeting of the Chicago Section, American Welding Society, held on the evening of February 17th. "Welding of Pressure Vessels" was the subject of an illustrated lecture by Jules Muller, chief engineer, Hollup Corp. E. B. McGuire, manager, Hamler Boiler & Tank Co., discussed "The Qualification of Welders" with particular reference to code requirements. A lively discussion followed.

## A. W. S. to Hold Its Fall Meeting in Detroit

The fall meeting of the American Welding Society will be held the week of October 2nd in Detroit, Mich., at which time the 15th annual National Metal Congress and Exposition will also be held in Detroit. Convention Hall will house the exposition. Other societies holding their meetings in Detroit during the same week are the American Society for Steel Treating, three divisions of the American Institute of Mining and Metallurgical Engineers, and the Wire Association. Others will probably also participate. During the week preceding this, the International Acetylene Association will be in annual convention in Chicago.

## California to Hold a Welding Conference

A welding conference will be held in the engineering buildings at the University of California on March 10th, the biennial Engineers' Day. On this day the College of Engineering holds open house for its friends. In addition to a program of papers, there will be demonstrations of welding technique and testing of welded specimens, in the afternoon. For the speaker at the dinner meeting, it is hoped to secure one of the men conducting an approved research project of the American Welding Society. F. P. McKibben, president of the Society, will deliver a paper before the conference.

## Testing and Gas Welding Discussed in Philadelphia

"Testing of Welds" was the subject of a paper presented by John J. Crowe, at the meeting of the Philadelphia Section, American Welding Society, held on January 16th. In addition to illustrating his talk with a number of interesting slides, Mr. Crowe provided some practical demonstrations of the testing of welds.

At the meeting of the Philadelphia Section to be held on February 20th in the auditorium of the Engineers' Club, the subject will be "Gas Welding." R. F. Helmkamp, of the Air Reduction Sales Co., will talk on "Mechanical Cutting and Flame Machining" and F. C. Clark, of the Linde Air Products Co., will speak on "Bronze Welding by the Oxyacetylene Process." Discussion will follow the two papers.

## Compressed Gas Assn. Holds Annual Meeting

A large and representative attendance was attracted by the twentieth annual meeting and dinner of the Compressed Gas Manufacturers' Association, held on January 23rd and 24th at the Waldorf-Astoria, New York Ctiy. The technical program centered upon the more recent and the prospective uses of gases in industry. The keynote was struck by S. D. Kirkpatrick in his presentation of "What's Ahead for the Compressed Gas Industries." Mr. Kirkpatrick, who is editor of "Chemical and Metallurgical Engineering," graphically depicted the future possibilities of compressed gases in air conditioning and other new and projected industries and developments.

Glenn O. Carter, of the Linde Air Products Co., in an interesting paper on "Oxygen and Acetylene Utilization by Other Industries" showed the extent of the dependence of major industries—petroleum, aircraft and chemical, in addition to the more familiar metal-working, railroad and shipbuilding fields—upon oxygen and acetylene in the application of welding and cutting.

"The Dependence of Industry on Bottled Gas," by D. B. Williams, of the Carbide & Chemicals Corp., and "The Commercial Applications of the Rare Gases and Nitrogen," by F. P. Gross, Jr., of the Air Reduction Sales Co., were among the papers included in the well-balanced program.

Luncheons were held on Monday and Tuesday noon. The always popular annual dinner, held in the Sert Room of the Waldorf-Astoria, and featured by entertainment arranged by W. F. McKay, chairman of the dinner committee, was attended by more than 170 guests. This event, held Tuesday evening, closed the twentieth annual session.

The following officers were elected at the annual business meeting: President, F. J. King, chief engineer, Linde Air Products Co.; 1st vice-president, F. A. Eustis, secretary-treasurer, Virginia Smelting Co.; 2nd vice-president, Eugen Becher, Metal & Thermit Corp., and secretary-treasurer, Franklin R. Fetherston.

# Rating Metallic-Arc Electrodes

■ By J. B. GREEN
President, Fusion Welding Corporation

Comments on the significance of recent specification changes and a suggestion as to the future trends.

DURING the past few years, some revolutionary changes have been introduced in the matter of appraising the relative merit of various brands of metallic-arc electrodes for welding mild steel. Prior to the termination of the World War, some 80% to 90% of the mild-steel welding done was accomplished by means of the oxyacetylene torch. There appears to be more gas welding done now than in 1918 but, during the fourteen intervening years, electric welding has so expanded the use of the welding art that, in percentage, it has exchanged places with gas welding and it probably represents 80% to 90% of the total today.

Gas-welding wire always has been made as free as possible of surface materials and, in consequence, a complete chemical analysis of the wire itself becomes a measure of its quality. Even today, complete analyses do not appear in specifications for such wire, and it is a question whether it ever will be expedient to ask the chemist to supply a complete analysis. A determination of carbon and manganese, together with an assurance from the analytical chemist that all other ingredients, except non-metallics, do not total over 0.20% with no single ingredient over 0.05%, is probably all that will be required to insure uniform quality. A welding operator can determine the solid non-metallic content so much quicker and cheaper than the chemist that a fusion test appears by far the most practicable. Fusion of a small quantity of rod under the torch indicates the presence of non-metallics. These non-metallics appear plainly on the molten weld puddle and take on one or more of three forms: floating white specks, blanketing scum, or entrapping slag. The presence of floating white specks is of no consequence either in the matter of the rate of welding or weld quality, but the other two forms of non-metallics should constitute a basis for rejecting a rod.

## Analyzing Surface Coatings

As the use of metallic-arc electrodes began to increase, specifications were quite naturally written around the analises of the rod, as was the case with gas wire. However, it was early discovered that surface materials on electrodes played a very important role in the matter both of operation and weld quality. This is true even of so-called bare wires and, in a larger measure, of flux-coated electrodes. In the matter of modern shielded-arc electrodes, the flux coating so dominates the operating characteristics and weld quality that the quality of the metal of the rod itself is of quite secondary importance. The analytical chemist has failed, in a practical sense, to provide a quick, cheap analysis of surface materials and flux coatings. Only a very few laboratories are capable of doing this sort of analytical work at all, and weeks are often required to complete a single analysis. Furthermore, an analysis of the coating on an electrode seldom tells the entire story. The coating thickness, its density, tendency to resist moisture, adherence to the rod, concentricity, tendency to burn even ended or lop sided, etc., are all important factors.

## Specifications Based on Physical Properties of Weld Metal

These matters have driven the specification writer away from expressing the basis of acceptance in terms of the analysis of the rod and coatings and induced him to rate electrodes on the physical properties of the weld metal obtainable. This is more or less unique in the matter of specifying manufactured articles in general. It is manifestly unfair to the supplier to rate his product on a basis of its use when the product itself is only one of many variables involved in the determination of quality.

In the case of metallic-arc electrodes, the physical properties of a resultant weld depend not only on the electrode itself but upon the skill of the operator, the characteristics of the generator, the quality and dimensions of the parent metal, the welding procedure employed, the technique of testing, etc. Thus the specification writer, in leaving the analytical chemist, and adopting weld quality as a working basis for determining merit, forfeits the right of rejection by the user and introduces a basis, adequate in principle, but costly, cumbersome and indecisive in actual practice if applied by any other than the highest-trained experts. In spite of the numerous well-founded objections to the weld-quality basis of rating electrodes, it still appears to be a decided step forward. It seems better to perfect the technique of applying the new basis of rating electrodes than to consider retracing the step already taken.

## U. S. Navy Method of Rating Electrodes

Only the largest fabricators possessing scientifically equipped laboratories and maintaining a highly trained laboratory staff can safely indulge in determinations of electrode merit on a basis of weld properties. Today, the U. S. Navy has probably carried the modern method of rating electrodes to the highest state of perfection, and the navy officers in charge freely admit they have much more to do before final perfection is attained. A brief description of the testing technique as at present employed by the navy in connection with rating shielded-arc electrodes will serve to illustrate merit rating procedure.

First, the electrode is run in flat, vertical and overhead positions, using currents and technique prescribed by the manufacturer. If nothing is noted which the operator considers might preclude practical use of the electrode, it is admitted to further testing. The arc must be reasonably stable, a workmanlike bead must be obtainable, no visible porosity present, etc. Tests are then made on the solubility of the coating in water, tendency of the coating to crack off, electrical conductivity, tendency of the coating to burn square ended, and on most other attributes of a merchantable electrode. Finally, the merit-rating tests are conducted. These are concerned with all weld-metal specimens made from each size of electrode. In the case of 5/32 in. and smaller, tests are made in each of the three positions, flat, vertical and overhead, while 3/16 and larger are tested for position only. The test specimens must show certain average minimum values as follows: Ultimate tensile strength, 65,000 lbs. per sq. in.; elongation, 20% in 2 in.; and specific gravity, 7.80 grams per cubic centimeter. If a brand of electrodes equals or exceeds these average minimums, it becomes eligible to a merit rating. For each size and position, the tensile strength in pounds per square inch is multiplied by 0.0001 (which is the same as pointing off four places to the left) and added to the percent elongation

and specific gravity. Thus, for any one size and position, the minimum merit rating is 6.5 + 20 + 7.8 = 34.3. Such ratings for each size and position are then added together and the sum thus obtained becomes the recorded merit rating for the particular brand of electrodes under test.

Purchase orders for navy requirements are awarded on a basis of cost per pound per unit of merit. The supplier bids a price per pound in the usual way, and the purchasing officer divides this price by the merit rating of the brand of electrodes in question, thus obtaining the cost per unit of merit. This method of awarding business introduces a powerful incentive to the electrode manufacturer to improve his product. The higher his merit rating, the higher price he can obtain per pound and still be the lowest bidder per unit of merit. The buyer gets his money's worth because he is really purchasing performance rather than mere pounds of metal.

In the navy rating, ductility is stressed to such an extent that the merit rating assigned to any one brand is affected by a change of 1% in elongation as much as a change of 10,000 lbs. in tensile strength. Other users will not necessarily find that the navy basis of merit fits their business as perfectly as some other might. For example, an outdoor contractor might be more interested in the resistance of an electrode to water damage than any other consideration, and he would stress this feature, as the navy has elongation. In the case of another user, some operating characteristic, as, for example, rate of deposition, might be paramount. Yet another user might decide that variety of work passing through the shop was the outstanding characteristic of his business so would want to stress the latitude of the electrode. The range of current, thickness of parent metal, variation in procedure, etc., which an electrode might permit and still give welds of suitable quality represent the operating latitude of the electrode.

## Cost of Conducting Tests

As stated above, very few users of welding are equipped either with laboratory facilities or personnel adequately to test the performance of electrodes. Even the few who are so equipped find the cost excessive. The cost of testing a single brand has been found to be about $300 when only the most significant factors are determined, and a complete test involving operating characteristics, latitude, etc., would probably run $1,000 or more. Operators must also be qualified for testing, and the cost per operator is as high or nearly so as that per brand of electrodes. Not every brand submitted in competition to a user nor every operator applying for work will qualify on a basis of the minimum requirements.

Thus a user who desires to admit several brands of electrodes to competition for his business and who employs several operators, will find that $5,000 to $10,000 quite possibly will be required if he adopts the modern method of rating. Expenditures of such sums can scarcely be justified. The electrode manufacturer cannot pay in such figures except by adding substantially to the selling price of his product, and it appears a needless waste for the individual shop to repeat tests made over and over again by other shops. There are no statistics available showing the amount of money spent by users of welding on testing electrodes. However, it probably is considerably more than might be required by some central laboratory equipped to conduct extensive tests on all brands of electrodes submitted. In fact, possibly only a portion of the money annually expended by the largest fabricators would furnish all the capital required to establish such a laboratory, and then its maintenance could be provided for otherwise.

Insurance underwriters are vitally interested in welding. Welding and cutting torches, welding generators and the arc itself are fire hazards. The light from welding, burns from welding and cutting, and electric shock are all hazards under workmen's compensation laws. Risk of explosion and collapse are insurable risks in the matter of pressure vessels, steel structures, etc.

## A Proposed Solution

The work of passing on the acceptability of welding and cutting equipment and supplies as well as articles and structures fabricated or repaired by fusion methods, is surely very closely related to that done by the Underwriters' Laboratories and might be readily annexed by that institution. Insurance underwriters should be vitally interested, and yet they are in a way entirely apart from the manufacturer of equipment and supplies as well as the fabricator employing welding. By selling labels for equipment and supplies and products fabricated by welding, as the underwriters now do for articles involved with fire hazards, the laboratory would probably be fully self-supporting and the burden would fall on each company in proportion to business done.

Much indirect as well as direct benefit and saving should come from such a laboratory. One comprehensive test of a brand of electrodes would cost far less than numerous partial tests made by hundreds of users all over the country. No user would consider the purchase of an electrode unless the test report of the Underwriters' Laboratories accompanied the sales solicitation. This would automatically force electrode manufacturers to present only rods of real merit. No salesman could profit by overstating claims for his product. Each user could select for himself those attributes of an electrode which make it desirable for his particular work and devise his own system of developing a merit rating. He could then quickly calculate the merit rating on any brand of electrodes from the figures contained in the underwriter's test report and, dividing by the price quoted per pound, would quickly determine whether the new electrode offers an advantage over what he has been using. The user could, as the occasion arose, make quick changes from one brand to another without interruption of shop work for testing and be sure he was moving toward something better. The competent electrode manufacturer would find a diminution of competition from irresponsible competitors and a quick, sure reward for improving his own product. More often than not, as much as one-third of the selling price of a brand of electrodes must be spent by the manufacturer as the expense of selling. This should be so materially reduced by placing the matter of sales squarely on a foundation of proven merit that the cost of the Underwriter's label could be borne and the selling price also reduced without reducing the manufacturer's profit. More, better and cheaper welds would surely result.

Estimates now available place the domestic consumption of welding rod at about 75,000 tons during 1929 and 15,000 tons during 1932, a drop of 80%. The production of iron and steel has fallen more than 80% during the same period. This indicates that, of the iron and steel produced, a greater percentage was fabricated by welding in 1932 than in 1929. The increase in this percentage is probably directly attributable to the introduction of the present modern methods of testing electrodes, welds and operators. If the high cost of applying these methods can be sharply reduced and the results made available to all without impairing their quality, another impetus should be given to the expansion of the use of the fusion welding processes.

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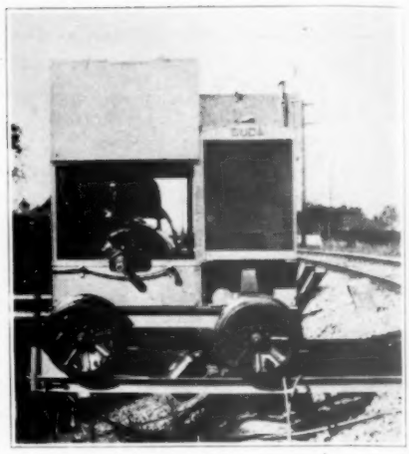
# Meeting of Australian Welding Institute

A series of short lectures on "Practical Oxy-Welding Jobs" was given by J. C. Thompson, J. Bremner, G. Oakley, J. D. Osborne, G. Reed, and W. D. Sandford at the January 24th meeting of the Australian Welding Institute in Melbourne.

# Welding of Rail Ends

## on Steam and Electric Railroads

■ By A. W. McCLARY
Hollup Corporation



Power Plant and Generator on Take-Off Frame.

Paper read January 20, 1933, before the Chicago Section of the American Welding Society.

THE building up of rail ends during this period of economic depression, is synonymous with economy. Our railroads are now in need of rebuilding or relaying their right-of-ways and are confronted wtih the problem of finances. The question of expenditures for maintenance of right-of-ways must be carefully weighed by the maintenance-of-way engineer. His responsibility is to maintain the tracks in as good condition as possible with the least expenditure of money. He has two alternatives—one, to replace worn rails on the main tracks with new rails, salvaging the worn-out rails by cutting the ends and using them for secondary tracks; two, to rebuild the worn rails to the original contours without much interruption to traffic.

The equipment necessary to successfully rebuild rail ends includes a generating plant which will supply the welding current and current for grinding the weld smooth and for slotting the rail ends. The selection of the proper equipment should be based on the merit of the equipment, on its first cost, and its maintenance cost. Either a. c. or d. c. equipment is available for rail-end welding. To obtain at the electrode sufficient power to properly weld, results in very high line losses where direct current is used. These line losses vary as the square of the current carried. To minimize these losses and to provide sufficient current at the electrode, large cables must be used. The a. c. power plant has an advantage where the unit can be small and still permit welding at a considerable distance from the generating plant.

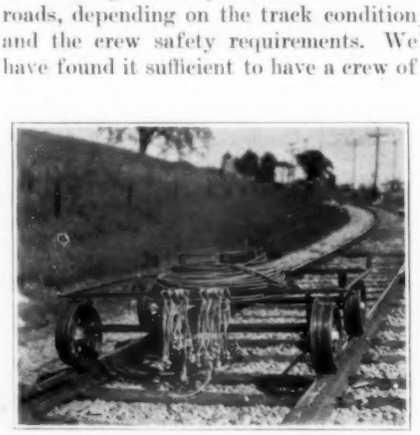
### Using High-Frequency Current

Another advantage which should not be overlooked is the possibility of using high-frequency current, thereby reducing the weight of the transformer at the end of the line and also permitting the use of a small cable up to the transformer.

The equipment which I am most familiar with, and which I have used for a number of years, consists of a 120-cycle alternator capable of delivering 250 amperes at the electrode. The grinder and slotter used to finish-grind the joint are of light construction. Their lightness, however, was not obtained at the sacrifice of rigidity or sturdiness. The rail grinder is purposely light in weight so it can be carried on and off the rails to clear traffic, by one man, if necessary. Its ease of removal from the track avoids unnecessary delay and loss of time from the grinding operation. The rail slotter is portable and one man can handle it as easily as an ordinary surface grinder.

### The Crew

The number of men in a crew necessary to carry on a successful job of rail-end welding will vary with different railroads, depending on the track condition and the crew safety requirements. We have found it sufficient to have a crew of four men when working a single-operator unit one shift a day. Such a crew will consist of one welder, one grinder operator, one flagman and one foreman. The welder's duty is to weld continuously, shifting the transformer along the track as he proceeds in his welding operation. The grinder likewise grinds steadily. The flagman protects the welder and the grinder from approaching trains and helps them move the equipment on and off the rail. The foreman attends to the power plant, lays out the transmission cable with the aid of a cable reel, and marks the joints which are to be welded; he bevels the joints with the rail slotter after the joints have been welded and ground, and checks each joint after beveling as to levelness of the grinding job and as to the quality of the weld; he makes a careful observation of the rail ends after they have been ground-polished by his beveling operation, to see if they are free from horizontal cracks or fractures. To the above personnel may be added an extra flagman, as some railroads require a flagman at each side of the crew, one watching for oncoming trains from one direction and the other from the other direction.



Cable Reel Mounted on Track Wheels.

### Operating Double Shift

When operating a single-operator unit two shifts a day, the crew consists of a power-plant attendant, a welder, a grinder and a flagman. The foreman, in this case, looks after the operations of both crews. He generally begins his day's work with the day shift and inspects the work performed by the night shift. He then proceeds to supervise the day shift but, at all times, arranges his moving to a new location during the day so as to facilitate the night work. The night shift, upon coming to work, generally finds the power-generating plant located, the cable strung out, and everything in readiness to proceed with welding, grinding and slotting.

The duties of the power-plant attendant are to look after the power plant, to lay the transmission cable ahead of the welder, and to grind and bevel the rail ends after they have been welded and surface ground.

The primary success of a two-shift operation lies in moving the equipment to

a new location in the day time. When the work is properly laid and the crew fully equipped with electric lights, the work can be carried on after dark as successfully as it is carried on by daylight. Operating a double-shift crew is the most efficient method of carrying on the work and enables one to get twice as much welding done with the same capital investment and requires a crew of only nine men.

## Three Methods of Repair

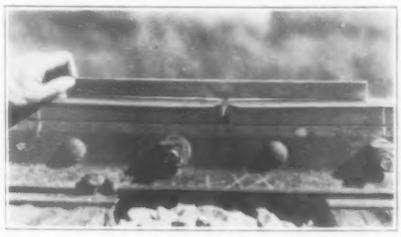
There are three methods of rebuilding the rail ends. The selection of the method and the procedure to be followed are, of course, left to the maintenance-of-way engineer.

*Method A*—This method consists of building up the low rail to its original size and contour and then reducing the height of the other rail. If the rails are worn at the ends, the amount of welding to be done is measured by placing a straight-edge on the rail end of the rail which shows the most wear. On a one-way traffic line this is almost always the receiving rail end. A straight-edge so placed will show the beginning of the wear by daylight appearing under the straight edge. This point is then marked, and the welder builds up the rail end to its original level with this point as his limit. If this rail, after being built up and ground, does not meet the level of the high rail, the high-rail end is ground down to a gradual slope to meet the level of the low rail just welded. Should the tip end of the high rail be battered to such an extent as to be lower than the level of the built-up low-rail end, this tip end of the high rail is also built up sufficiently so as to finish the grind to the level of the low rail. In any case, the height of the two rail ends should be the same, and these two rail ends should be level when bridged with a straight edge. A foreman with sufficient knowledge can determine whether or not both rail ends at a joint requires building up at the time he lays them out for welding.

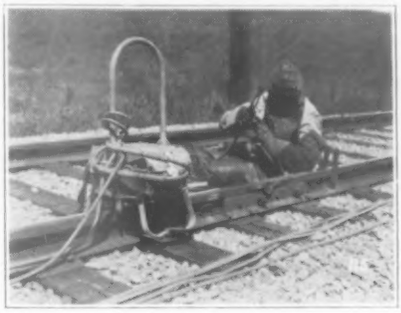
*Method B* — This method consists of building the crossover with a taper on both rails—that is, building up the low rail to a size above its original level and leaving the high rail lower than it was originally. The amount to be built up on the rail end can also be determined by bridging across the joint with an 18-in. or 24-in. straight-edge and marking each rail where wear is shown or where any daylight appears under the straight-edge. The building up of the rail ends is limited to the distance between these two marks. The weld is then ground straight and is inspected by placing a straight-edge across the welded ground joint. In grinding this joint correctly, the low rail is increased in height slightly and the high rail is sloped downwards a little so as to strike a happy medium between the two rail levels. It is obvious that in sloping the high rail, some of the amount of daylight under the straight-edge will be lessened in length; therefore, the foreman, in marking this joint, should make allowance for the amount of worn surface which will not need to be built up. This will shorten the amount of welding to be done.

*Method C* — This method consists of rebuilding the high rail to its original size and contour and building the low rail on a long taper to meet the level of the big rail. The amount of welding to be done is marked as in method "B"; but in grinding, the low rail is raised to meet the full height of the high rail by a long gradual slope to produce the necessary run-off on the low rail.

## Sequence of Operations in Building Up Rail Ends



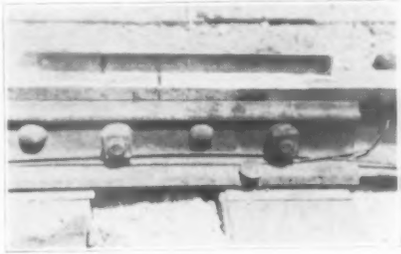
FIRST: The foreman checks the worn joints and chalks off the extreme limits between which the weld beads are to be laid.



SECOND: The welder locates his transformer and ground, and proceeds to build up the rail ends between the two chalk marks.

THIRD: The grinder operator grinds the balls of the rail ends to a smooth, even contour.

FOURTH: The foreman bevels the joints with the rail slotter and then inspects the joint.



FINALLY: The finished joint is true and free from cracks.

## Comparison of Methods

The advantages and disadvantages of the various methods of marking and rebuilding are as follows:

Method "A" reduces the amount of welding to the minimum, but it also reduces the height of the rail balls to the lowest of the two. The greatest fault of this method is that the grinder operator gets into the habit of being careless in grinding this low rail a trifle lower, and then he grinds the high rail down to the same level in order to obtain a level crossover for the two rail ends. This is particularly bad, as some of the good wearing surface of the rail is ground off and a smooth riding crossover is not always obtained.

Method "C" increases the amount of welding to a maximum. It is also very difficult to grind the long gradual run-off slope on the low rail, which is necessary to obtain a smooth crossover.

Method "B" is taken up last, as it is desired to emphasize this method. This method increases the amount of welding slightly over method "A" and reduces it considerably under method "C." It is the easiest joint for the grinder to finish, and it also insures against grinding the low-rail ball below its original level. If properly ground, the low-rail ball is, in fact, raised in height slightly. Neither of the rail balls is reduced or raised to a maximum or minimum as in method "A" and method "C." Method "B" gives what we might call an average height at the rail ends. Such average height is bound to be a distinct advantage in the case a broken rail has to be replaced. In such case the new rail is apt to conform more nearly in height with the ends of the adjoining rails. The riding quality of the crossover obtained with method "B" is excellent.

The size of the electrode to be used for welding depends upon the welding unit available. There is, however, a maximum

and minimum limit to the size of welding rod suited for this type of work. Assuming that the power available at the electrode holder is sufficient to considerably fuse or melt a 5/16 in. electrode, we must determine whether a 5/16, 1/4, 3/16 or 5/32 in. electrode should be used. The writer prefers a 3/16-in. electrode. The rail end does not heat up as much when using this electrode as when using a larger electrode. The welder has a greater opportunity to build up his weld and, at the same time, bring it to a feather edge at the beginning of the worn surface. Variations in welding current have less effect with a 3/16-in. electrode than when using a larger electrode; that is, when welding near the generating unit, where the line losses are small, the electrode performs equally as well as it does when used at the far end of the cable.

## Electrode Requirements

Inasmuch as the welding operation is dependent upon the quality of the metal deposited as well as its hardness, let us consider what the requisite of a good electrode should be. The electrode should give good penetration as well as being of a type that will permit the deposition of a very thin layer without a change in the amount of current delivered at the electrode. The deposited metal should be protected with a slag while at the high temperature, and this slag should be readily removable as soon as the metal has cooled to or below 1400° F. The metal deposited should have a good wearing quality and should have a capacity for work hardening. As soon as the weld is completed, it should have sufficient initial hardness to prevent batter and toughness so as to retain some ductility after having work hardened to its maximum hardness. The work hardening feature of the deposited material is very important. A freshly laid deposit should lend itself to the grinding operation without excessive wear on the grinding wheel and still possess a Brinnell hardness sufficient to withstand a high load pressure due to traffic. The deposit should be of such a nature as to have a coefficient of expansion similar to that of the rail metal so as to prevent checking or cracking upon cooling. After work hardening to its maximum hardness, it should not be brittle nor should it exfoliate from the rail metal.

## Quality More Important Than Cost

The cost of such a welding rod is sometimes of paramount importance to the purchasing agent. However, the maintenance-of-way engineer should be more interested in the quality of the material than in first cost. It will be eventually less costly for him to purchase a 20c per pound rod with the proper merits than to purchase a 6c per pound rod with no merit at all.

The grinding of the rail is done with a track grinder. The original contour of the rail is maintained in the built-up material. The deposited metal is sufficient in thickness to permit grinding to a smooth surface when the operation is finished. Beveling or slotting of the rail end is very important to the success of the job. Such an operation will also greatly lengthen the life of the newly laid rails as it prevents chipping at the top of the ball edges and thus eliminates rail batter. During the summer months when the expansion of the rail causes the ball edges to come in abutting contact before the balance of the rail face abuts, any deflection at the rail joint due to traffic will be particularly harmful at the top edge of the ball. Such deflections place a severe strain on the small portion of the rail ball. These stresses, together with the compressive stresses due to load, tend to cause horizontal cracks to form at various depths below the surface of the rail ball, and these cracks sometimes extend the full width of the rail ball. The beveled faces, whether they be obtained by using a thin emery wheel or produced by a special shaper tool, prevent this condition.

## Supervision and Inspection of Work

The prime reason for welding and grinding the worn and battered rail ends is to make the joint ride smoothly and prevent impacts inherent to depressions at the crossover. A job half done is not much better than no job at all. Proper supervision and inspection of the finished work are, therefore, very important. A ground joint or a partially smooth joint with a sufficiently high spot to cause a severe hammering of the car wheels may withstand the hammering and not batter to any extent, but the results sought have not been achieved unless the joint is so finished as to provide smooth riding as well as resistance to batter. A joint welded in length for 6 in. when the worn distance is actually 12 in. will resist the batter but will not ride smoothly until it is welded over the full area and ground to a commercially perfect level. Smooth ground joints increase the pleasure of riding, decrease the cost of section labor in tamping up the road level at the joint and tightening the angle bar bolts, reduce the wear of the angle bar under the head of the rail, and eliminate splitting of the tie and replacing of bond wires. It is, therefore, very essential that the reconditioned rail joints be made to ride smoothly. This is why every welded and ground joint should be carefully inspected by an experienced foreman in charge of the equipment. This inspection should be done before the equipment is removed to a new location, in order that any joint which does not pass inspection can be rewelded and reground immediately. The foreman also inspects each rail end closely for horizontal fracture. The smooth ground surface left at the ends of the rails after the beveling operation, enables him to see the horizontal fracture. The oxidation that takes place in such cracks is visible in the form of a hair line, and all such fractures should be either chipped with a track chisel or burned out with the welding arc and rebuilt by the welder, ground smooth and rebeveled.

## Cost per Joint

The cost per finished joint is a variable, depending upon the method used in rebuilding the crossovers, the number of persons required in the crew, and other factors. The cost per lineal inch of welding seems the most accurate method of comparing cost and will vary with the process used. The oxyacetylene and electric process are both used for this type of work. The efficiency of the electric equipment, the skill of the men doing the work, the traffic condition, and the depth of batter have an influence on the cost. Roughly speaking, by employing the electric process and carrying on the work with trained men under average traffic conditions, the cost of labor and material per lineal inch of weld will vary from 9c to 10c. This does not include any charge for depreciation of the equipment.

The cost of rail-end welding by other processes is not entered into here. The cost of any process which will produce smooth riding joints will seldom be less than that of electric welding. It is admitted here, however, that the low cost of welding electrically is obtained when 30 per cent or more of the joints are welded.

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## Program and Exhibits on Stainless Steel

The origin, structural differences and commercial development of chromium and chromium-nickel steels, their corrosion and chemical resistance, high-temperature service, welding and other means of fabrication, structural purposes and general applications will be covered in addresses by Dr. Marcus A. Grossman, research engineer, Illinois Steel Co., and D. T. Haddock, consulting engineer, American Sheet & Tin Plate Co., to be given before a joint meeting of four engineering societies, of which the Philadelphia Section of the American Welding Society is one, to be held in the Crystal Room, Elks Hotel, Philadelphia, on the evening of February 23rd. L. N. Mockel, chairman, Philadelphia chapter, American Society for Steel Treating will preside. A feature of the meeting will be an extensive exhibit of stainless-steel products, which will open at noon of the same day.

# Using Tubes as Structural Members—II

Second in a Series of Three Articles

IN A previous article of this series, it was pointed out that one of the chief essentials of bolted or riveted joints is that members should overlap one another or overlap a common member—for example, a gusset plate. It is obvious, therefore, that tubes presented in the past grave objections to the structural designer on account of the difficulty of making a proper fastening at each end of the tube.

Various attempts have been made to get over this difficulty. A Dutch engineer makes the ingenious proposal that the tubes should be specially shaped into angles and tee sections by hot or cold pressing in the forge. Bolted structures on these lines have been erected in some parts of the world, but the idea has obvious limitations since special dies have to be available at the constructor's works, and, together with hydraulic press or steam hammer, are required whenever a length is cut off for use as a structural member.

## Welding Simplifies Joining of Tubes

Clearly, therefore, any method of fastening which demands a change of shape along the length of the tube has very serious limitations; and unless this is present, bolting and riveting are almost impracticable. An alternative is, of course, to screw onto the ends of the tubes specially shaped jointing pieces which in turn can be bolted, riveted or screwed together, but the additional expense involved in all these operations and in the special parts required clearly puts this alternative altogether out of

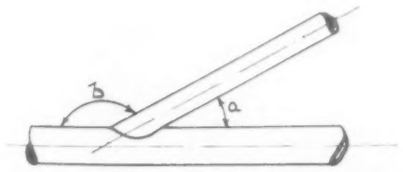



Fig. 3. Conventional Tubular Acute-Angle Joint.

consideration. The advent of welding has given a considerable impetus to the use of tubes as structural members, and we have had much evidence to show that the properties of the tube as a structural member have been appreciated by structural designers—for example, bicycle frames are assembled by brazing together tubes into special connecting pieces, airplane structures are welded together from tubes by shaping their ends especially to suit one another and are welded for the most part in jigs. Similarly, motorboat frames, motorcar chassis, and other structural parts of moving machines, where a high ratio of strength to weight is important, are now welded together from tubes.

ABSTRACT from a paper by Aubrey F. Burstall, Engineer in Charge of Welding, and Harold Kennedy and Reginald A. Smith, Assistant Engineers, Welding Department, Imperial Chemical Industries, Ltd., Billingham, Stockton-on-Tees, England. This paper was awarded a $100 prize in the Second Lincoln Arc Welding Prize Competition, sponsored by The Lincoln Electric Company, Cleveland, Ohio. A total of $17,500 was awarded in this competition. The sponsors plan on publishing the leading papers submitted in the prize contest in book form at a later date.

With reference to the bicycle, the difficulty of joining together the ends of the tubes is overcome by the use of special sockets which are brazed to the tubes which require no special preparation as the joint is usually an overlapping one. A similar type of joint is used in tubular metal scaffolding, though the jointing piece is then not brazed but clamped to the tube by means of a bolt and introduces eccentricity at the joint. The screwing of the tube and the jointing piece or socket has long been familiar to the engineer as the standard method of joining tubes or pipes for carrying fluids, but this method of connection is seldom used in structural work except for handrailing, for which, on account of their smoothness, tubes are almost invariably used. The use of overlapping connecting pieces, whether screwed, brazed or welded, has the objection that the weight of the structure is considerably increased, since at all the connecting points the thickness of the tube is doubled for the length of the overlap. Moreover, a large stock of special connecting pieces must be kept on hand if structures of widely differing sizes and load-carrying capacities are to be constructed with their use. Lastly, the cost of the connecting pieces is very large, as everyone knows who has purchased fittings for steam, water or gas piping.

The method of connection adopted in airplanes, which is usually to weld the tubes directly to one another, having previously shaped them to fit, has the great objection that it is exceedingly costly.

An ingenious method of joining tubes consists of slotting the tubes to take a connecting plate which passes through the center plane of the tubes being joined. This method is very costly, as is also the welding up of the ends of the tubes that are exposed when the strength joint has been completed. One of the superior features of this type of tubular joint, as compared with joining the tubes directly to one another, is that a uniform section of fillet weld can be employed between the tube and the joining plate. If one considers the cross-section of a weld between two tubes joined together, as in Figure 3, it will be seen at once that the cross-section of the weld varies all the way round the circumference of the joint from an acute angled fillet weld at *a* to an obtuse angled weld at *b*, with an infinite variety of shapes in between. It is, therefore, almost impossible to use any type of gage for checking the size of the weld between two tube connections, and the shop superintendent is forced to rely upon his own and his welder's experience as to whether sufficient material has been added at every joint. This is a serious drawback on production work, as the use of gages for fillet welds on structures is very advantageous both to the welder and the inspector or shop superintendent.

## Difficulties in Calculating Weld Strength

Furthermore, the usual method of calculating the strength of structural welds is to multiply the length of the welded deposit (less a constant for the craters) by the depth of the throat of the fillet from the hypotenuse to the corner opposite to it and to multiply the product of these

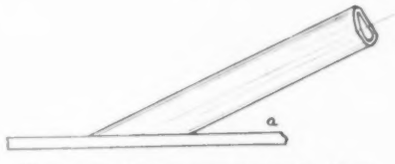



Fig. 4. Tubular Acute-Angle Joint on Flat Member.

two figures by the allowable stress in the weld material. Such calculation is impossible where the cross-sectional area of the weld material is not constant and where even the length of the weld is exceedingly difficult to determine.

In making a weld between two tubes of the type shown, it is also difficult for the worker and the supervisor to estimate the degree of penetration that has been secured in various parts of the joint. This trouble is particularly in evidence

when tubes are joined at an angle to the flat surface of structural members; for example, it is difficult to secure penetration at the bottom of the acute angle *a* in Figure 4.

Lastly, there is a danger when tubes are welded together that they are not properly centered before welding and, therefore, that there will exist an amount of eccentricity at the joint far greater than was allowed for by the designer. On airship structures, for example, one frequently meets with a welded cluster of tubes (see Figure 5) where it is exceedingly difficult for the erector to determine whether he has fixed all the tubes

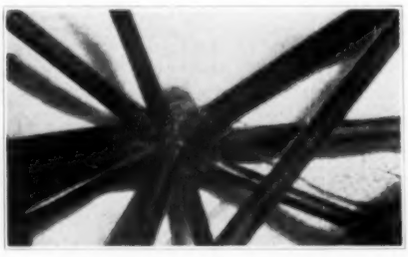


Fig. 5. Welded Cluster of Tubes.

with their center lines meeting at a point before he commences to weld. A welded joint such as that shown in Figure 5 has the further drawback that excessive overheating occurs owing to the large number of welds to be made in one place.

## Influence of Cost on Use of Tubes

Perhaps the gravest objection to the use of tubes as structural members is to be found in their greater cost per unit of weight as compared with steel plates or other structural steel sections. The reason for the high cost of tubing in the past, particularly for tubes of small sizes such as are required for structural work, is to be found in the greater number of operations to which the steel has to be subjected before it is finally suitable as a structural member.

In most countries, steel tubing of the type suitable for structural work is at present produced by hot rolling and piercing from the billet or by lap welding. The more expensive cold-drawn tubes such as are used for airplane structures are obviously too costly to be considered as structural members except in those cases where reduction in weight is a paramount necessity as in the instance cited. It is usually possible to purchase structural steel sections such as angles, channels, tees, etc. for the same price per ton as rolled steel plate because the rolling operations involved in making the plate are just as costly and in some cases more costly than the rolling operations needed to produce the structural steel section. It is, therefore, apparent that where tubes are used as tension members in place of flats or other common structural sections, the cost of material in the tubular tension member will always be greater than the cost of the equivalent flat or angle member of similar strength. It is true, however, that lighter sections can be used when tubes are employed on account of the reduction of surface and corrosion, as explained in the previous article; and the consequent smaller minimum thickness will, therefore, produce a lightening of many of the sections. In addition, the absence of eccentric loading of the tube will lighten the tubular tension member as compared with an angle.

In spite of this, the cost of steel tubes of the sizes and quality required for structural work is only slightly more than twice the cost of rolled steel sections of the same weight.

The proposal put forward by the authors to overcome the difficulties previously outlined in the use of tubes as structural members, is as follows:

## Spheres and Polyhedrons for Joining Tubes

The tubular members are to be united by welding them to a common intermediate member in the form of a regular polyhedron or a sphere, to the surface of which each of the tubular members is joined at right angles, the line of contact being a circle. As in Figure 6, it is thus possible to reduce the welding operation required to a single type which is of the

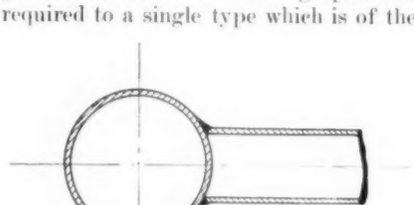


Fig. 6. Section of Joint Between Tube and Sphere.

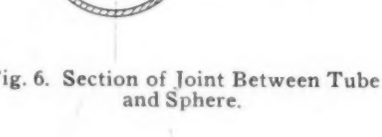


Fig. 7. Tube Passing Through Sphere.

simplest kind. The intermediate polyhedral or spherical member, which for the sake of lightness is usually hollow, may suitably be fabricated from scrap-plate by welding. As far as the sphere is concerned, the authors have found the most convenient procedure to be to join two die-stamped hemispheres. The diameter of the sphere should exceed the diameter of the widest tube to be affixed to it by at least 50%. It is of course possible to join together several tubes through the medium of a single intermediate polyhedral or spherical member, the size of which is chosen in accordance with the size and inclination of the tubes to one another.

According to a further modification of the same proposal, the joint between two tubular members may be made at the intermediate point of the length of one of them by providing a polyhedral or spherical collar, the internal diameter of which is such as to allow it to be passed over the one tubular member and to be

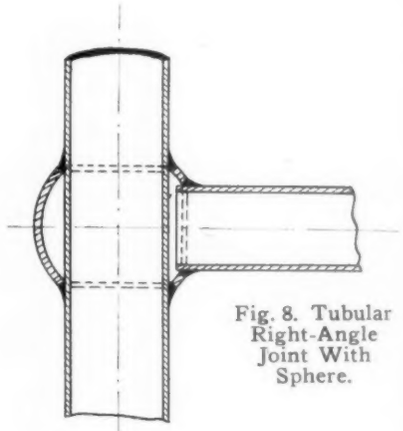


Fig. 8. Tubular Right-Angle Joint With Sphere.

welded to it (see Figure 7). In this instance the second tubular member is affixed to the surface of the polyhedral or spherical collar in the normal manner, as in Figure 6, or as shown in Figure 8. It is, of course, possible to join several side tubes to one common tubular member, and the adoption of the collar referred to avoids the necessity for extra cutting and aligning operations.

## Spherical Joint Pieces Provided With Projections

In some cases it is expected that the intermediate spherical members will have to be provided with projections on their surfaces, as shown in Figure 9, or be drilled with holes in order to assist the erection of a structure in a comparatively stable form, preparatory to the actual welding, and, in this instance, the tubular members to be joined may be welded to the projections, or to a vee cut into the intermediate member as shown in Figure 10. It is anticipated that these last modifications will be particularly necessary in the case of tall buildings or large structures where stability of the structure prior to welding is of great importance.

A further modification of the authors' proposal consists in using as intermediate connecting members a portion only of one of the shapes referred to. For example, tubes may be joined together in some cases by bent plates, as shown in Figure 11, and these intermediate members can readily be made on the site and can also be used as brackets for the fixing to the structure of any article with a flat surface which for other reasons it is

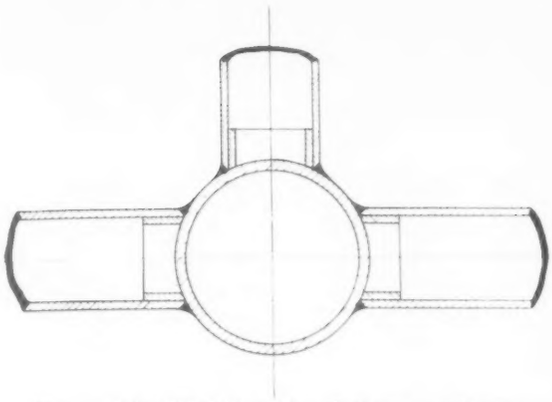


Fig. 9. Joint With Locating Collars on Sphere.

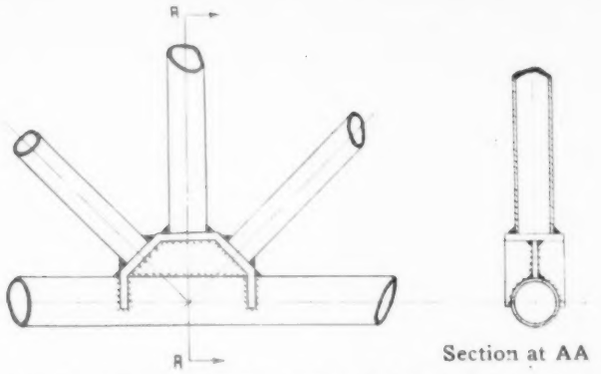



Fig. 11. Joint Between Tubes, Using Polyhedral Joint Piece.

not desired to weld directly to the structure.

This method of fixing objects to a structure by welding brackets onto its members is a fundamental feature of the proposal and is a logical result of the property of welding as a "putting on" tool. In every case it is proposed that a plate or bracket should be welded to the structure instead of drilling a hole when anything has to be fixed to the structure. The former course of action is of course preferable to the latter from all points of view.

## All Tube Ends Can Be Cut Square

One of the most outstanding features of this proposal is that the expense of preparing the ends of the tube for welding is very much reduced. In every case the tubes are cut off square, since there is never any necessity to do otherwise, because of the property of a sphere that its cross-section in any plane is a circle and fits the periphery of a tube placed upon it from any direction. At first, the authors intended that all tubes should be cut off square with a saw, which is, of course, a very simple and inexpensive operation. Subsequent experiments have shown, however, that the additional operation of bevelling is desirable on all tubes of more than 1/8 in. in wall thickness to make certain of obtaining adequate penetration in the welding operation right through to the inside of the tube. This bevelling, however, is again a very simple and inexpensive operation, and both the cutting and bevelling in a structural shop could be done on mass production lines.

It should be noted that by the older methods the special preparation of the ends of tubing for welding is necessary both for joining tubes to one another and for joining tubes to flat members except when they are at right angles to the axis of the tube.

Owing to the geometrical properties of tubes and spheres already referred to, the section of the weld between them is always the same, and hence the welding operation itself and the subsequent gaging of the weld are both enormously simplified. This has the further advantage that less skill is demanded, since the same type and size of weld are used all round the circumference of the tube. It follows, of course, that the strength of the joint is now determinate and, provided that the welder secures adequate penetration to the bottom of the vee and that the finished weld meets the requirements of the gages, we can be certain in every case that the welded joint is stronger than the tube. This property is particularly important for aircraft where uncertainty of the strength of a weld may lead to loss of life.

## Overcoming Problems of Alignment

It was mentioned previously that one of the difficulties of welding tubes together was the virtual impossibility of making sure that they are properly

Fig. 10. Sphere Drilled and Beveled.

aligned before welding so that no eccentricity is introduced at the finished joint. Normally, this means that special jigs must be used at all the joints. But when spheres are employed it is comparatively easy to ensure that no eccentricity occurs at the welded joint. For instance, the welder can be certain that if the tube is touching or at the same distance from the sphere at all points of its circumference, then the center line of the tube must pass through the center of the sphere. Thus any eccentricity due to misalignment is avoided; and when it is desired to join two tubes in the same line on opposite sides of a joint, the sphere itself provides a very convenient base on which the necessary marking out can be done with a few simple tools.

## Large Spheres Eliminate Overlapping of Tube Ends

Excessive overlapping in a tubular airplane structure is difficult to avoid by the usual methods of joining where a number of members come to a common point. These difficulties also are overcome by using a large sphere as the center of a common point and joining all the tubes to its surface. In such a case, unless the tube ends are to be deformed and pieces cut away from them, both of which are undesirable, it is necessary that the diameter of the sphere should be large enough to accommodate all the tubes without their touching. It will then be possible to make all the welds on the surface of the sphere without any excessive overheating. A comparison of the two methods of joining is to be found in Figures 5 and 12.

A further advantage of the spherical joint is that there is no sudden change of direction of the lines of stress, and hence no stress concentration at the joint, as is common when tubes are welded to one another.

To the welding engineer the simplest method of making the hollow sphere is obviously by welding together two drop-forged hemispheres which themselves are made from plate. All that is required for the first operation are suitable dies for the sizes required, and a drop hammer and heating furnace for the plate blanks. After drop forging, the hemispheres are drilled in the center for holding in a capstan lathe for machining their edges, and the drilled hole is later used for location purposes.

The method of welding adopted for the center weld between the two halves of

the hemisphere will depend generally upon the number required; but as large quantities will almost invariably be manufactured of each individual size, it is almost certain that the quickest and cheapest welding process which can perform the same operation with unfailing regularity and certainty will be employed, and for such a repetition process resistance or flash welding will usually be selected. This method was used by the authors for manufacturing other spheres, and therefore special copper holding chucks had to be provided to take them in the flash-welding machine (see Figure 13). Moreover, it was necessary to provide the extra metal for melting and upsetting in the flash-welding process so that the finished sphere would have the required dimensions. After welding, the spheres were as shown in Figure 13, each having an outside radius of 2 in. and a wall thickness of 3/16 in. It was in the flash-welding operation that the locating holes were required in each hemisphere so that they could be correctly held in the jaws of the flash-welding machine. After the flash-welding operation it only remains to machine off the outside bead on the surface of the sphere. The inner one may be allowed to remain.

Had an automatic machine been available, the authors would have tried electric arc welding of the center joint in the sphere, which might compare favorably in cost with the flash-welding process which was employed. It would possess the additional advantage that less material would be required in the drop-forged hemispheres, as no allowance would then have to be made for upsetting; and as extra metal would be added by the metallic-arc-welding process, the depth of the dies used for making the drop forgings would be reduced, which would effect a further saving both in cost and maintenance on the dies. Unfortunately, however, such a machine was not available and therefore automatic arc welding was not employed, the only alternative of hand welding being too costly.

## Layout for Mass Production of Tubular Structures

The new proposal for fabricating tubular structures lends itself particularly well to the adoption of mass production methods for building structures for the following reasons:

(a) Uniformity of shape of sections
(b) Simplicity of operations to be performed
(c) Adaptability of procedure to the use of jigs
(d) Lack of templating required due to welding
(e) Adaptability to the use of gages.

The methods employed in a production shop where the suggested procedure is

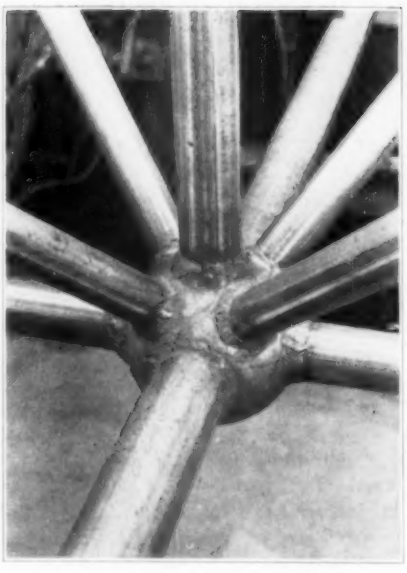


Fig. 12. Cluster of Tubes Welded to Sphere.

in progress would be for the tubular stock to come in at one end of the shop, where it would be cut off to length with a circular saw or cutting machine, and bevelled, and the spheres and the cut-off tubes would be delivered to the assembly table, where they would be placed in the correct position with clamps or jigs and then welded. The practice of tack welding after assembly is quite unnecessary where proper clamps or jigs are employed; and it is preferable, where possible, to complete the welding operation immediately after assembly so as to avoid any movement of the parts after they have been placed in the proper position. Gages would, of course, be used both by the welder and by the supervisors or inspectors who were passing the work. Proper precautions must always be taken to avoid distortion as with any other type of welded structure.

## Field Erection Is Simplified

For erection in the field, tubular structures possess the great advantage of being easily handled both on account of their lightness and because of the round shape of the section. Consequently, larger pieces can be handled than with the usual type of structure, and as a rule several welding operations will be carried out on the ground at the site before lifting into position, as the shop-welded work is necessarily limited in size by transport considerations.

For holding these large welded sections —such as a roof truss, for example—in position while welding, the locating pegs will be drilled. Holes in the spherical joints will be employed in the manner already explained, but the number of these will be kept to the minimum on account of cost. It is, of course, possible to avoid the use of these special locating members by using the crane for holding such parts as roof trusses in position while they are welded, but usually this course is inadvisable as it reduces the speed of erection.

## Wall Thickness of Spheres

It is hardly necessary to state that the spheres used for structural work need not be solid to withstand the stresses that will be imposed upon them by connections to comparatively thin tubes. On the other hand, there is a limited thickness below which the spheres will collapse due to the stresses imposed by the connecting tubes. The authors used 4-in. spheres as a standard for experimental work. The wall thickness of these spheres was 3/16 in., which is comparable with the thickness of tubes to which they would be connected, though rather thicker than most sizes, and a convenient thickness for manufacturing. Subsequent tests of these standard spheres, described later, showed them to be of adequate strength for the tubes with which they have so far been used; but it is of course desirable that the stress in all parts of the spheres should be calculated for various loads and various sizes of tubing, though up to the present a solution of this complicated problem has not been reached from theoretical considerations.

It is suggested by the authors that as a rough and ready rule the spheres should have an outside diameter of one and a half times the diameter of the largest tube with which they are used and

Fig. 13. Copper Chucks for Resistance Welding of Sphere, and View of Welded Sphere.

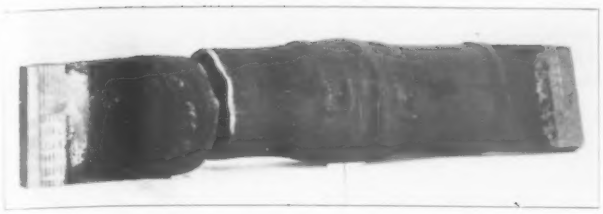


Fig. 14. Tested Joint of 4-In. Sphere and 3-In. Tubes.

Fig. 15. Tested Joint of 4-In. Sphere and 2-In. Tubes.

that the thickness of the sphere should not be less than one and a half times the thickness of any tube to which they are connected. These rules no doubt make the sphere walls rather thicker than is necessary, but this is desirable until more complete tests have been made.

In order to facilitate actual design, tables of the weights of hollow steel spheres of various diameters with different sizes of holes have been drawn up. [These are included in the original paper.] An additional table has been compiled showing the least possible angle between two tubes at a spherical joint for different sizes of spheres and tubes. From this table the minimum size of sphere for any joint can quickly be determined.

## Tests of Spherical Joints

In order to test the spherical joint design, three tensile specimens were made. These consisted of short lengths of tubing having outside diameters of 1, 2 and 3 in. and welded to 4-in. spheres. The principal dimensions, details of end connections for holding in the grips of the testing machine, and the results of the tests are given in the accompanying table. In the case of the 1-in. specimen, the tube and screwed end connection was turned from one piece of mild steel. Figures 14 and 15 show two of the tested joints and Figure 16 is a section of a joint. All the specimens broke in the tube *away from the weld*, thereby developing the full strength and making the best use of the tubes. In all three cases the ultimate stress in the tube was the mean of the specified limits of the ultimate strength of the material of the tube. Thus the 2-in. and 3-in. tubes failed at 55,200 lbs. per sq. in., while the 1-in. tube failed at 67,000 lbs. per sq. in. The welds showed no sign of failure. The claims that the spherical joint develops the full strength of the members of the structure are, therefore, justified. The joint is superior to the ordinary rolled-section joints and tubular joints, which tend to fail at the joint near to the weld due to the sudden change in the direction of the load lines.

The permanent set in the diameters of the spheres along the axes of the joints at the ultimate load was negligible for the 1-in. and 3-in tubes. These results are easily explained. When the tube is large relative to the sphere, the stress due to

Fig. 16. Section of 4-In. Sphere Joined to 2-In. Tubes.

bending in the sphere is small. With tubes that are small relative to the sphere, which has a thickness designed for large tubes, the load to be carried by the sphere is so small that the sphere is slightly stressed, with a resulting negligible deformation of the sphere at the ultimate load of the tube. These conditions do not apply to the 2-in. tube specimen (see Figure 15), the sphere of which showed an axial elongation of 0.135 in. at the ultimate load of the tube and a negligible elongation at the yield load of the tube.

RESULTS OF TENSILE TESTS OF SPHERICAL JOINTS

| | | | |
|---|---|---|---|
| Tube, outside diam., in. | 1.344 (actual) | 2.375 (nom.) | 3.5 (nom.) |
| Tube, inside diam., in. | 1.024 (actual) | 2.00 (nom.) | 3 (nom.) |
| Actual cross-sectional area, sq. in. | 0.597 | 1.31 | 2.18 |
| Ultimate load, lb. | 39,900 | 73,750 | 124,000 |
| Ultimate stress, lb. per sq. in. | 67,000 | 56,250 | 56,700 |
| Ultimate strength of tube material, lb. per sq. in. M. S. | 62,800-71,700 | 53,800-58,300 | 53,800-58,300 |
| Sphere, outside diam., in. | 4.00 | 4.00 | 4.00 |
| Sphere, inside diam., in. | 3.625 | 3.625 | 3.625 |
| Cross-sectional area across diam., sq. in. | 2.25 | 2.25 | 2.25 |
| Stress across diam. of sphere at ultimate load, lb. per sq. in. | 17,750 | 32,700 | 55,150 |

## The Institute of Metals to Hold Annual Meeting

The Institute of Metals, London, England, which this year celebrates the 25th anniversary of its founding, will hold its annual general meeting in London on March 8th and 9th. The Institute announces that the annual May lecture will be given by M. Albert Portevin, president of the Société des Ingénieurs Civils de France, who will speak on "Quenching and Tempering Phenomena in Alloys." The lecture will be delivered on May 10th at the Institution of Mechanical Engineers, Storey's Gate, Westminster.

## New Officers of Los Angeles Section A.W.S.

The regular annual business meeting and election of officers was held by the Los Angeles section of the American Welding Society on January 19th. The retiring chairman, Turner C. Smith, and M. H. Turner, secretary-treasurer, presented their annual reports of the section's activities, which dealt with the progress and development of welding, regulative codes, specifications, ethics, etc.

The following officers and members of the Executive Committee were elected for the coming year: Chairman, Ben M. Laulhere, engineering supervisor for the Southern California Gas Co. Vice-chairman, Frank A. Longo, welding supervisor for the Southern Pacific Railway Co. Secretary-treasurer, M. H. Turner, of the Home Oxygen Co. (re-elected). Executive committee: T. C. Smith, assistant engineer, General Petroleum Corp.; M. E. Canfield, manufacturing agent, Ried-Avery Co.; Frank L. Howard, testing engineer, Smith-Emery Co.; C. E. McGinnis, general manager, Board of mechanical engineers, City of Los Angeles, and Carl M. Olsen, assistant chief engineer, Western Pipe & Steel Co.

An interesting feature of the meeting was a talk by Frank A. Longo, newly-elected vice-chairman, on "Economies Effected by Welding in the Railway Industry." An interesting and instructive talk was also given by Willis Swift, engineer, American Brass Co., and director of the American Welding Society, on the subject, "Bronze Welding."

# The "Sky-Ride" Portends Construction for Structures

**AS THE twin towers for the giant "Sky-Ride" at A Century of Progress Exposition slowly rear their heads to dominate the sky line of Chicago's waterfront, the two leading consulting engineers on the project were asked what the construction of the "Sky-Ride" portended for the future, with particular reference to its effect on welded construction. Here are the interviews with Dr. W. D. Steinman of Robinson and Steinman in New York, designers of the thrill ride, and Joshua D'Esposito, well-known builder of the Union Station in Chicago and consulting engineer for the project, as given to a reporter for publication in *The Welding Engineer*. The welded features of the "Sky-Ride" were described in last month's issue.**

## Interview with Dr. Steinman

*Q.*—"Dr. Steinman, please tell me what in your opinion are some of the outstanding features of the 'Sky-Ride' your firm designed for the Chicago World's Fair and what promise this design holds for the future."

*A.*—"Well, young man, an outstanding feature of the 'Sky-Ride' is the design of a suspension system in which all members are tension members. There is no design like this anywhere in the world, and it adequately demonstrates that tension is the most efficient form in which steel can be used. This span is developed with ropes alone, which development is disposed to restrain deflection and produce a smooth, easy-riding span.

"The application of this design, in which all members are at tension, will enable us to build longer spans with greater economy. Employing the same materials as we are using on this job, it would not be an especially difficult feat to construct a span ten times the 1,850-ft. span of the 'Sky-Ride.'"

*Q.*—"Now, Doctor, is there anything especially significant in the methods being used by the various contractors in the erection of these unusual towers?"

*A.*—"Yes. Probably the most significant development in the erection of the 'Sky-Ride' is the recording of the practicability of welding in high tower construction. The twin towers are the highest in the world in which welding is employed almost exclusively in the fabrication of the steel.

"This extensive use of welding has made for a simplification of detail, economy of weight, which is a very important consideration, and speed in construction.

"There is no question in my mind that this piece of work being done by the Mississippi Valley Structural Steel Company is the most important advance in the development of welding in recent years, and is surely leading the way to its more extensive use in the future for all types of buildings. This company has developed its own machinery for this purpose and turned out a remarkable piece of work in the welding processes."

*Q.*—"And, Doctor, because the weight of the towers is of such importance, how have you overcome useless ornamentation so that the towers would be both beautiful and practical?"

*A.*—"Mr. Reporter, the 'Sky-Ride' is an outstanding example of the comparatively new idea in structural design that steel towers can be made pleasing to the eye and economical. If the routine design of bridges had been used in this instance, the structure would have been out of keeping with the modernistic trend of the Fair. By giving thought and study to the aesthetic phase, a pleasing structure has been secured.

"Even in the bracing of the towers, an effect of harmony and rhythm is achieved—the rhythm, by using principles of repetition and alternation of pattern.

West tower of the "Sky-Ride" in course of erection. The large municipal stadium is in the background, with a wing of the Field Museum visible at the right.

# General Acceptance of Welded

## . . . Say NOTED ENGINEERS IN AN INTERVIEW

The structure, when completed, will be a splendid illustration of functional beauty. In our design, we eschewed meaningless ornamentation. Not one pound of metal is wasted in these towers. Each bit is doing its work and the whole is made beautiful by the careful assignment of each part."

*Q.*—"Now in conclusion, Doctor, what purpose will the 'Sky-Ride' serve other than providing the big amusement thrill of the Chicago Exposition?"

*A.*—"The construction of the 'Sky-Ride' is not the result of whim or caprice, but rather it is the development of careful planning for the future. It has ever been the history of successful business to find new outlets for materials and services during 'hard times.'

"These companies, The John A. Roebling's Sons Company, The Otis Elevator Company, The Great Lakes Dredge and Dock Company, The Inland Steel Company, and the Mississippi Valley Structural Steel Company, have an eye to the future. It is not their desire to go into the amusement business but to demonstrate the feasibility of this type of construction as a utility. This structure can be designed competently to take the place of expensive bridges crossing rivers and streams. The question of carrying heavier loads merely means a change in the cable size. The 'Sky-Ride' is much more than an amusement feature. In our opinion, it is definitely pointing the way to the huge suspension bridges of tomorrow."

### Interview with Joshua D'Esposito

*Q.*—"Mr. D'Esposito, what do you feel about the 'Sky-Ride' you fellows are building over at the World's Fair?"

*A.*—"I know it is as ticklish a job as there has been in the country, and that it has more possibilities for the future than any job with which I have yet been associated. You know, there is no precedent for it, and, consequently, a great deal of original research was required. Some of our problems at first defied mathematical analysis."

*Q.*—"What were some of the problems you speak of?"

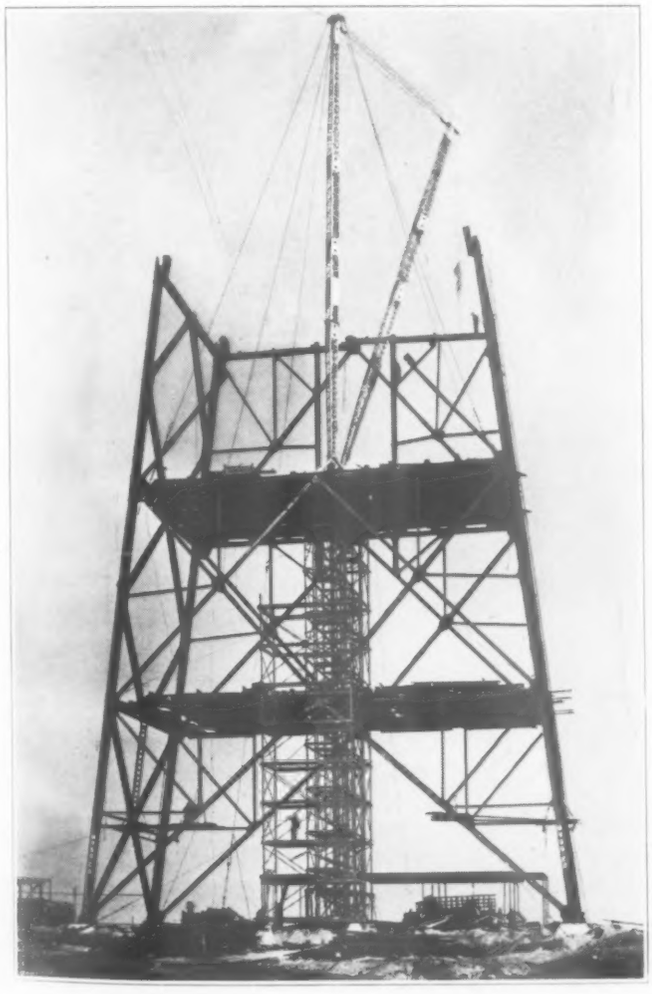
*A.*—"One of the most vital problems we had to solve in planning for the towers was the question of weight. At first, there was considerable prejudice to the proposal that welding be employed in the fabrication of the steel. But after a visit to the plant where the work was to be done, all objections were swept aside. We are proving in the erection of the steel for the 'Sky-Ride' that welding is thoroughly practicable for high tower construction. It has never been used so extensively in this manner before and we are thoroughly satisfied. In my opinion, this development is the most significant in the history of the welding processes. It has brought a new outlook on this important question to engineers, fabricators and erectors alike.

"Why, the anchoring of the tower ropes alone required months of preparation. You see, temperature conditions change the length of the cables and in order to compensate for any possible change, we had to work out a system of 500-ton counterweights to be placed at the anchorage of each tower. These anchorages are half a mile apart. This arrangement of design may provide the means of a span at so much lower cost than a bridge that there is no comparison.

"As I estimate it now, the 'Sky-Ride' type of construction, to take the place of bridges, would be about one-tenth. The whole idea, could, without difficulty, be worked out as an aerial ferry.

"You see, the capacity of a standard type of bridge is seldom used. It costs just as much to build a bridge to carry one vehicle as it does to carry a thousand. And taking into consideration the financial condition of the national and many of the local governments, the matter of future public construction will depend largely on price. At many points in the country, spans are needed but the money for an expensive bridge is not available.

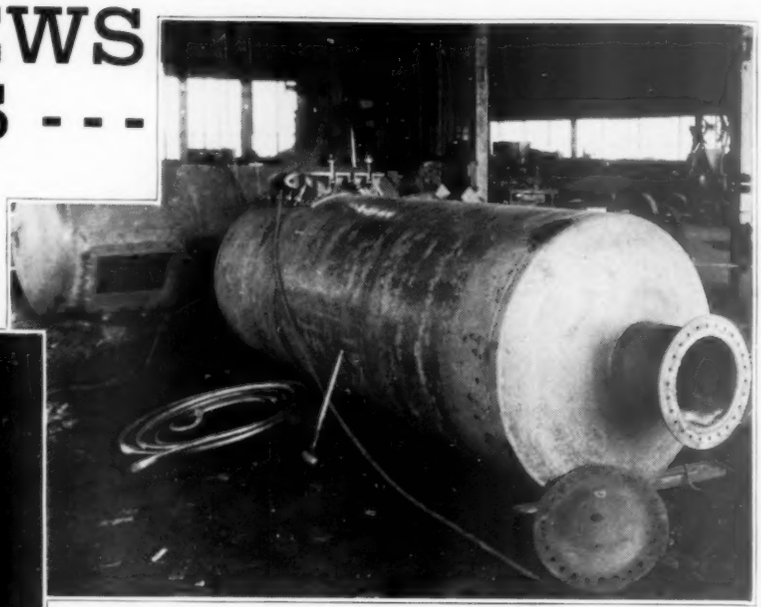
"The 'Sky-Ride' is much simpler in design than a bridge and presents many different problems, but it can be built cheaper and it can be developed practically as a bridgeway. In my opinion, the 'Sky-Ride' will remain forever in the minds of engineers as a monument to progress in engineering."

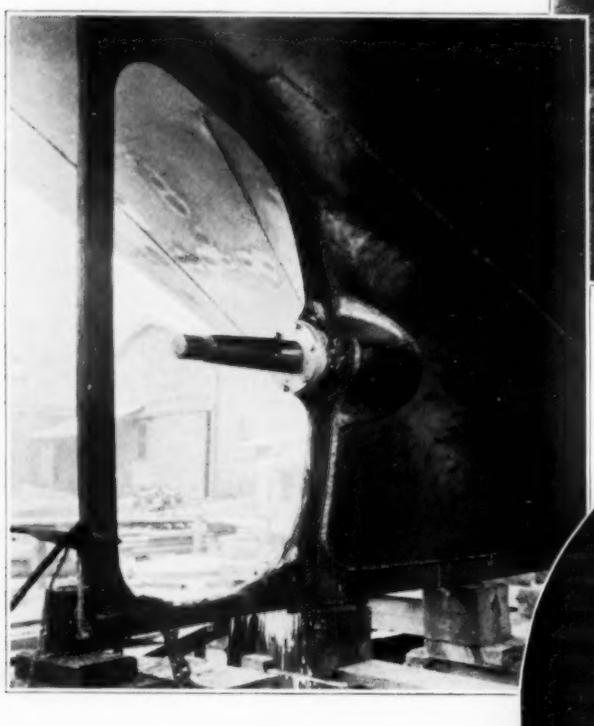


East tower being erected on Northerly Island in Lake Michigan. These towers will be 625 ft. high and 1850 ft. apart. The structure is shop-welded and field-riveted and bolted.

# WELDING NEWS IN PICTURES - - -

(Below) Under view of stern end of tug-tanker, showing welded construction and monel-metal screw shaft.

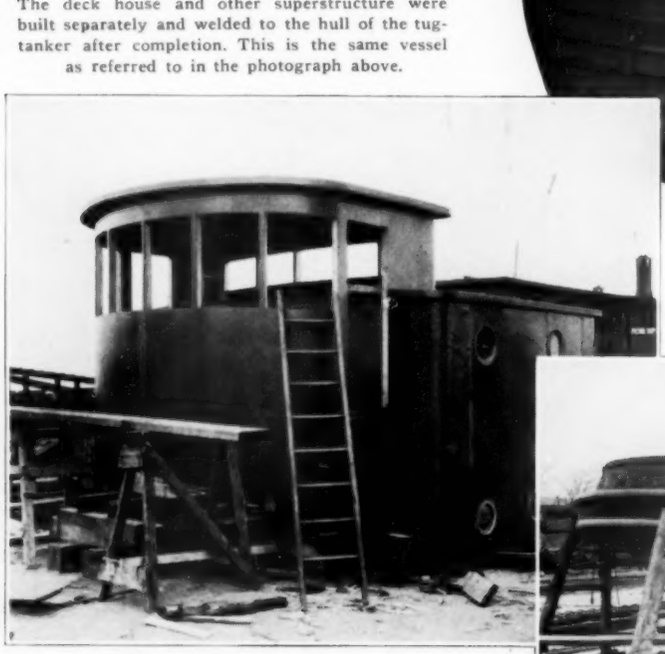




All-arc-welded extractor, fabricated in the plant of The Birmingham Boiler & Engineering Co., Birmingham, Ala.; for The Phoenix Naval Stores, in Gulfport, Miss., for the manufacture of chemicals for the Federal Government. The welded joints are tested against leakage.

The deck house and other superstructure were built separately and welded to the hull of the tug-tanker after completion. This is the same vessel as referred to in the photograph above.

All-welded blower 98 in. in diameter, consisting of 120 blades 9 in. wide and measuring 24½ in. from rib to rib. Built by the Campbell Heating Co., of Des Moines, Iowa.



Welded hull of tug-tanker, 64 ft. 11 in. long with a moulded breadth of 29 ft. and a cargo capacity of 36,320 gallons, nearing completion in the Jacobson & Peterson Shipyard, Brooklyn, N. Y., and designed by Brown & Demarest for the Lewis Coal & Oil Co., of Port Washington, L. I., N. Y. The Smith lock-notch system of construction was used.

# Refrigeration and Air Conditioning Make Strides With Gas Welding

THE necessity for reducing production expense in the manufacture of domestic refrigerators has focused more attention on the efficiency and application of welding operations.

Not only have the older manufacturers continued to use oxyacetylene welding and increased its scope, but new units of welded construction have appeared, sponsored by companies which could adapt existing facilities to the production and marketing of domestic refrigerators.

The long-recognized fact that oxyacetylene welding is essential in turning out refrigeration units with joints of absolute and permanent gas-tightness, and refrigerator cabinets and liners that can be perfectly enameled with entire elimination of unsightly and unsanitary cracks, has placed this industry in a very enviable position with manufacturers of mechanical refrigeration units. Makers of icing refrigerators are realizing the importance of improved cabinet and liner construction with the result that welding should become the standard for this type of unit as well as for the mechanical type.

## Welding in Commercial Refrigeration

In the commercial refrigeration industry welding has continued an important method of construction. The revisions of the A.S.M.E. Unfired Pressure Vessel Code have opened new possibilities for welding in the larger refrigeration installations which should prove valuable to the welding industry as activity increases.

One of the refrigeration manufacturers is now offering an all-welded ice can, whereas heretofore all such cans have been riveted. Undoubtedly, other manufacturers will soon be welding ice cans. The number of these cans made each year for replacement purposes is sufficient to make an appreciable outlet for welding gases.

Maintenance and repair welding on existing systems is becoming increasingly important, as is also the conversion of iced refrigerator cars for the transportation of food. Mechanical refrigeration for these cars, as well as cooling and air conditioning installations for passenger cars, will undoubtedly open new avenues for oxyacetylene welding.

The future for oxyacetylene welding in refrigeration and its newly allied air cooling and conditioning industry appears entirely satisfactory. There is considerable present and potential business from this group; and it can be felt with satisfaction that oxyacetylene welding has been of assistance to the manufacturer, not only in solving technical difficulties of construction, but in adjusting production costs to meet present marketing conditions.

**OXYACETYLENE welding is ideally adapted to construction of the component parts of air-conditioning systems and heating and air-conditioning units, states the report of the Oxy-Acetylene Committee presented at the annual meeting of the International Acetylene Association, held in Philadelphia, Pa., November 16-18, 1932. This article is an excerpt from that report.**

Cooling and air conditioning units for single-room use are on display in the larger cities. A typical single-room air conditioning unit which will hold the temperature down to 75 deg. F. and relative humidity down to 55% during hot summer weather, can now be purchased and operated at reasonable cost.

## Air-Conditioning Equipment

The integral parts of air conditioning systems to which welding may be applied can be classified as follows:

1. Fans (furnace and ventilating).
2. Temperature and humidity controls.
3. Air filters.
4. Humidifiers for warm-air furnaces.
5. Refrigerating compressors and coolers.
6. Air conditioning manufacturers, unit type.
7. Air conditioning manufacturers, air washer-blower units.
8. Air conditioning manufacturers, warm-air furnace system.
9. Humidifiers (cabinet or radiator type).

It has been prophesied that within five to ten years the present type of domestic heating installation will be entirely obsolete and will be supplanted by a modified type of hot-air heating plant integral with an air-cooling and air-conditioning unit. Whether or not these units will reflect the physical characteristics of present hot-air heating systems is a point of present controversy. It is, however, obvious that one primary feature of construction will be ducts to carry warm or cooled air at relatively low pressures and low velocities but in substantial volume. These may be built integral with the building construction or may be installed as supplementary equipment, utilizing normal partition thickness.

Of course, air-conditioning installations in restaurants, theaters, hotels and other points of group assembly, as well as in many major public buildings, office buildings, and factories, have become common practice. In such instances greater volumes of conditioned air are handled, and the problem of circulation involves higher pressures and relatively higher velocities.

In either type of installation the duct must be of metal. In the past these have been mainly of galvanized iron and have often been assembled by riveting. Currently, however, the trend in design seems to be in the direction of the use of thin rust-resisting sheet steel.

Oxyacetylene welding is ideally adapted to construction of the joints in either of these types of material. For galvanized sheet, bronze welding is commonly used, welds in square ducts being made usually at one corner. Circumferential welds, or welds which must necessarily be in the center of a side panel, are made on the basis of a flanged design, welded from one side only. For mild steel or alloy steel, bronze is sometimes used, but more frequently rod of similar characteristics to the base metal is employed.

## Leak-Proof Joints

Oxyacetylene welding, of course, renders such joints leak-proof. This is an important contribution to the efficiency of the structure. Tight joints additionally prevent the infiltration of dust or other foreign material.

It is not beyond the realm of reason to predict that with the increasing popularity of air conditioning, especially in domestic installations, mechanical oyxacetylene equipment will be designed not only to weld longitudinal seams but also to join certain types of circumferential sections that might be adaptable to mechanical handling. However, even at the present stage of the development of welding in this application, oxyacetylene

welding has many advantages over all other methods of joining metals.

For the other features of air-coditioning equipment in addition to ducts and sheet metal parts, oxyacetylene welding offers its usual important advantages.

Its applicability to pipe, pressure vessels, and especially to the fabrication of ferrous and non-ferrous alloys, makes this process of vast importance in this growing field.

## "Phusion Phantasy"

*By* C. J. HOLSLAG

Have you ever stopped to think why welding welds and why fusion fuses? Why do some metals unite readily when fused by the arc, gas or thermit welding process, others not so easily, and some require fluxes or absolute cleanliness or both? Why will mercury, tin, lead and antimony (the bases of solder and bearing metals) merge with almost all metals, and why is the same true of certain bronzes? Strangest of all, why will phosphor bronze, fused by the arc, run together nicely with copper, but Tobin bronze will not? The hypothesis that I have to offer, while not any of the accepted ones, does I think explain many such mysteries regarding intergranular cohesion.

When a substance changes from a liquid or paste to a solid or dry form, in practically every case the formation and growth of crystals is very plain when viewed under the microscope. Make a solution of half table salt and half water and put a few drops of it in the sun to dry; then watch the crystal growth under a reading glass. The tree-like crystals, which form all through the solution, send branches out in all directions and these grow into each other. This interlocking and intertwining is the feature of crystal growth that holds substances together and gives them their strength. Thus metals, with their interlocking crystals, have what we call tensile, compression and sheer strength.

As a graphic illustration, the crystals of manganese steel when given a certain heat treatment show barbs on the ends of the crystal growths, so they cannot pull apart so easily. Hence such steel has twice the strength of ordinary mild steel.

Steel as obtained in this country is a conglomerate crystalline growth of iron, carbon, manganese and certain other impurities that probably do not add to its strength. For example, the carbon and perhaps the manganese add to the desirable properties, while sulphur and phosphorous do not, and silicon is expected to be neutral. However, silicon in certain amounts and heat treatments makes the best magnet iron and electrical laminations; and carbon, the beneficial element used with practically every steel combination, reduces the strength when used in the proportions found in cast iron, and when this 3 per cent or 4 per cent is exceeded the resultant combination has no strength at all. The answer is that when too much of some kinds of crystal growth is formed it separates the stalks or vines of the original strength metal, just as too much glue is not as strong as a smaller amount.

This crystalline growth might be likened to a lush growth in a tropical forest, being a tangle of roots, stalks, branches, and vines. When we cut the structure and look at the section under the microscope, or examine a microphotograph, we see only one plane, and what we call grains are the sections of the stalks, roots, or vines that we see in the plane of the cut. Some of these are cut at right angles, others lengthwise, and still others at various other angles, but such a superficial examination does not show the intertwining, since we see only a flat, dead, opaque section.

Applying this theory, we might say that carbon in small amounts cements together by filling in and interlocking, while in larger amounts it separates the stronger vines and substitutes weaker roots of itself. Manganese, with its barb-like crystals, makes steel stronger provided a certain time is allowed by heat treatment so the crystals can grow as desired. Hence a manganese steel weld will not have the same properties as the parent manganese steel unless the proper heat and time are given the weld deposit. Manganese welding is further complicated by the manganese wanting to elope with oxygen, and that is why $O_2$ or $O_3$ is bad around a weld. Oxygen, having no morals, will unite with any metal, and hence it must be kept out of the steel family life if there is to be any strength in the resultant weld. Furthermore, such desirable impurities as titanium, vanadium, chromium, and tungsten are continually trying to escape, and the arresting of the escaping couples shortens the growth time so that very often no growth of the culprits results, and, upon etching, the oxide or nitride or cyanide can be seen caught in between the good vines, thus weakening them. There are good impurities such as nickel which not only grow in spite of temptation but will compel manganese, chromium and vanadium to behave properly by its example. Nickel will make manganese steel grow its vines properly and, alloyed with chromium and vanadium, will grow properly without manganese under almost any condition, good or otherwise.

This theory says that mercury amalgamates readily with other metals because it is more dense than the metal it enters; for example, it can get in between the roots of copper. Brazing is the same action at a little higher temperature, and so is soldering. In gluing, the crystals form upon drying and enter into the wood, paper, or whatever is to be glued. By the same token that mercury, lead and tin enter easily and make good joints, the lighter metals, such as aluminum, magnesium and diecast metals, are very hard to join. These lighter metals would probably merge with steel, only for the difference in melting points.

These crystalline stalks are very small, and evidently the smaller the better, as fine grain crystals result in better physical properties. Heat treatment allows the crystalline stalks to settle more firmly into place and to continue their growth. If the heat treatment process is extended over too long a period or the temperature is too high, the crystalline growths sometimes deteriorate or they form defined cluster areas, or large grain growths.

Different temperatures produce various kinds of vine growths, just as climatic conditions make different forest and jungle growths.

In welding, the effect of heat-treatment growth, caused by the action of subsequent layers, is to change the existing vines into growths giving better interlocking properties, without affecting the parent metal. This is best exemplified in arc welding and next in gas welding, while in the other fusion processes it is absent because while the weld vine families are growing the parent metal often deteriorates. Tempering, which is easily explained by this theory, results from the vines being unable to adjust themselves but being frozen into strained positions. Mechanical working aligns the vines into order and gives ductility or tenacity, while stressing beyond the elastic limit (that is, beyond the natural root interlocking) causes the families to split up into groups called large grain growth or crystallization. In wrought iron, this splitting up is carried on until it is visible to the naked eye.

The hypothesis outlined above does not conflict with any of the electronic-ionic theories regarding the ultimate matter of which these crystalline stalks and vines are composed.

## Talks on Construction and Cableways of Sky-Ride

At the meeting of the Western Society of Engineers to be held on February 27th, 7 p.m. in the Engineering Building, Chicago, E. T. Blix, chief engineer, Mississippi Valley Structural Steel Co., will speak on "The Sky-Ride at the World's Fair," and will describe in detail the shop welding of this famous structure, which when completed will be the highest steel towers in the world in which electric welding has been used in the fabrication of the structural steel. Capt. A. M. Jones, designing engineer, John A. Roebling's Sons Co., Roebling, N. Y., will describe the cable system employed to support the overhead tracks between the two towers.

# · E D I T O R I A L ·

## Can It Be Welded?

● New alloys are continually under development. In work shops and laboratories all over the country, research is progressing in the attempt to find new combinations of metals that will produce new results. After a new alloy has been found, it is of no value unless it can be sold in the form of plates, castings, tubes, rods, rolled sections, or some other form. The salesman, in introducing the new alloy, often runs up against this question, "Can it be welded?" If the answer is Yes, and if the proper welding procedure has been worked out, an important barrier standing in the way of sales has been hurdled. The large companies with extensive laboratories know the value of weldability, and they develop alloys in so far as possible with that in view, but the small concern or the metalurgist working on his own responsibility often overlooks the high importance of weldability. They have not yet acquired the sales slant. If a product is good in their eyes, they assume it will sell. They overlook the fact that tensile strength, resistance to corrosion, and cost, are not the only important factors that the buyer weighs before selecting his material. There are some alloys on the market with very desirable characteristics that cannot be welded with a high degree of success because of the unfavorable action of the welding heat—a result that cannot be corrected by subsequent working or heat treatment. This unfavorable circumstance prevents such alloys from being used as widely as one might think they deserve, considering their physical properties alone. Their fabrication is necessarily limited to riveting and caulking, or soldering with specially designed joints to retain strength and at the same time insure tightness. Imagine trying to fabricate a heater of nickel-clad steel without welding! Or an 18-8 stainless-steel pasteurizer! In fact, the increasing popularity of some well-known alloys is attributed in no small measure to their workability and their weldability.

## Wanted—Welded Homes

● Descriptions of welded houses that have appeared from time to time during the past three or four years, and claims put forward by their designers and builders, have led to a high interest among contractors and designers in the welded house, some of whom expect that this will be the means of starting the construction industry on another boom like that of eight years ago. The wise ones who enter the business of building welded homes will first obtain plenty of financial backing to carry them through their first jobs, or they will investigate thoroughly before risking all they have and maybe losing their shirt. Appearance, cost, comfort and upkeep are factors that the home builder must give particular attention to if he would sell his buildings. In so far as welding will affect these factors favorably, to that extent will it be used. Sketches, blueprints and suave talk alone can't sell homes. An intimate understanding of those things that the home owner desires must be translated onto the drafting board before he will become interested, and even then the first efforts are apt to be at the contractor's expense. But with encouragement to the designer to strive for beauty of line, and to the layout men and welder foreman to systematize the work to the end that costs will be cut, the all-welded steel house will then be accepted by the home-buying public. The possibilities in the field are stupendous, and the careful planning evident in the house recently erected in Solon, Ohio, shows what can be done even today.

## Balance Those Budgets!

● With lots of money still available for buying, as the bank statements show, and with many millions still stowed away in hoarding, the question arises, What will induce the individual and the corporation to buy? All that is needed is the willingness on their part to buy. Therefore, anything that will inspire confidence and promote a sense of security will aid buying and will increase business. And that is just where this matter of balancing the budget enters. Nothing can promote confidence and a willingness to buy in such times as these so much as a knowledge that the business is operating in the black—that even though income may be small, expenses are slashed still lower. It may seem paradoxical that cutting expenses will actually promote buying. The explanation is that a balanced budget means that reserves need not be used for actual operating expenses, and hence these reserves can be drawn on for retiring obsolete equipment or making other changes that will result in operating economies. On the other hand, if the reserves are steadily being drawn on to make up the difference between income and operating expenses, even this use of reserves will be made very reluctantly. Balance those budgets!—not only governmental budgets but corporate and personal budgets as well. When that is done, industrial activity will begin to increase to such an extent that everybody will know it and we won't have to depend on statistics to tell us that the business index is rising. Moreover, employment gains made after budgets are balanced are apt to be sound in nature and permanent; those gains made while expenditures exceed income are just as apt to be short-lived. A balanced budget begets confidence, and buying follows in the wake of confidence. Those who today are spending more than they are receiving are not only a menace to themselves but to society as well. They are the millstone around the neck of industrial recuperation. We are pulling out of the depression in spite of them, but they make the going hard.

# New Equipment

## New Design of Vulcan Flame Cutter

The new Vulcan Flame Cutter, manufactured by the Vulcan Engineering Co., Jackson, Mich., and sold by the Weldit Acetylene Co., Detroit, Mich., has several changes in design compared with the former device, particularly in the tracing head and torch controls. The machine illustrated has a working surface of 24x36 in. and can cut material from ¼ to 8 in. thick. This machine weighs about 900 lbs. The base is designed to give a high degree of rigidity. The cast-iron side members support the tracing table and the bridge assembly carrying the tracer unit and cutting torch.

The ability to cut successfully with city gas and oxygen is said to be one of the outstanding features of this machine. It is claimed that the usual city gas pressures are sufficient without the use of booster units. Acetylene, natural gas,

Vulcan Shape-Cutting Machine.

butane, hydrogen, or unrefined coke-oven gas can also be used as the preheating agent, it is reported.

A graduated radius bar makes circle cutting entirely automatic. For cutting odd shapes, a full-size pattern or drawing is affixed to the tracing table and the stock is placed on the base beneath the pattern. The torch is adjusted for height by turning a small wheel on the torch holder. The plate is cut to identical form as the operator follows the lines of the pattern with the tracer unit.

The tracer head is driven by a 1/30-hp. motor operating from the lighting circuit, and the speed of cut can be varied from 3 to 20 in. per minute to suit the thickness of the stock. Machines of larger and smaller capacity than the one illustrated can be supplied.

## Hollup A. C. Equipment for Railroad Track Welding

For reconditioning worn and battered rail ends, crossover surfaces, switch points, and any worn track surface in the yards or along the main line, the Hollup Corp., 3333 West 48th Place, Chicago, Ill., has developed a full line of equipment including a portable gasoline-engine-driven generating plant, transformer, cable, turn-table, take-off frame, cable reel, electrically driven grinder, and electrically driven rail slotter. The equipment, though light, was built to obtain

Power Plant for Track Welding.

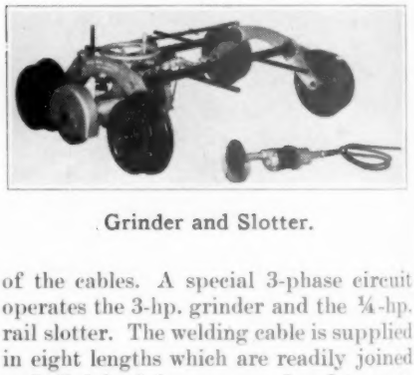
sturdiness so but few spare parts need be carried for replacement, and to be operated with maximum efficieney with a crew of four.

The complete track welding unit, including auxiliary equipment, is towed to the location by means of a railroad motor car, on which the crew of four men rides. Arriving at the location, the crew sets the take-off frame into position alongside the track and by means of the turntable the generating unit or power plant is set up on this frame. The motor car is then lifted off the rails, and the cable is strung by means of the reel carriage mounted on track wheels. The length of welding cable permits operating over one-half mile of track with each set-up of the generating plant. First, the joints are measured and chalked, then welded between the limiting chalk lines, then ground to the proper contour, and finally slotted and inspected. The light weight of the generating unit eliminates any need for cribbing built out of railroad ties to stand the weight.

The open-circuit voltage at the arc is only 50 volts, which is quite harmless. When the arc is struck the voltage applied to the transformer is automatically increased by the tripping of a mercoid switch. All circuits are said to be amply fused and well protected, and all armatures or rotors are dynamically and statically balanced.

The Hollup Corp. estimates that 50 12-in. joints or 80 6-in. joints can be completed per day with this equipment, although the actual number welded depends upon the process, the efficiency and training of the crew, and the prevailing traffic. The cost data given below are based on records covering the actual reconditioning of 25 miles of track.

The alternator is driven by a 40-hp. gasoline engine with a self-starter. Because of its ample capacity and the low line losses in the cables, this generator is said to deliver an arc current of 250 amp. steadily at one-quarter mile from the power plant, which is the extent of reach



Grinder and Slotter.

of the cables. A special 3-phase circuit operates the 3-hp. grinder and the ¼-hp. rail slotter. The welding cable is supplied in eight lengths which are readily joined and disjoined by means of safety connectors. The transformer is said to produce an arc that is easily controlled; it is light in weight so it can be easily handled by one man, and is mounted on rollers so it can be moved along the ball of the rail.

| | Cost per Day Dollars | Percent | Cost per 6-in. Joint | Cost per 12-in. Joint |
|---|---|---|---|---|
| Welder | $ 8.50 | | | |
| Grinder | 7.50 | | | |
| Gas Engine Man | 6.50 | | | |
| Flagman | 5.00 | | | |
| Total Labor | $27.50 | 64% | 34.5c | 55c |
| Rail Electrodes | $10.00 | | | |
| Gasoline and Oil | 3.50 | | | |
| Emery Wheels | 2.25 | | | |
| Total Material | $15.75 | 36% | 20c | 31.5c |
| Total Labor and Material | $43.25 | 100% | 54.5c | 86.5c |

## Increased Capacity for All Hobart Arc Welders

Under the slogan, "Count the Kilowatts," Hobart Brothers, Troy, Ohio, are announcing that all models in their line of arc welders will be available on the same increased-capacity-rating basis that has proved so extraordinarily effective in connection with their 400-ampere model for the past year and a half.

In addition to more powerful motors to guarantee the 60 per cent increase in welding capacity, the new models are provided with new drip-proof housings

New Hobart Welder.

with 3-point louvre ventilation. In addition to thorough protection with exceptionally cool operation, the new design is very much improved in appearance, and is symmetrical and well balanced.

Other features are reverse-polarity switch with double-scale meters, selective reactance, and remote control. Exceptionally high efficeincy, power factor and wide welding range are claimed for the new line, as well as uniform welding current, quick arc recovery, great arc tenacity, and freedom from sticking and splattering.

The new models are available in capacities ranging from 5 kw. (125 amp. at 40 volts) to 24 kw. (600 amp. at 40 volts), with electric-motor or gasoline-engine driven drive, as well as for pulley or coupling drive.

## Prospectors Find Hard-Metal Ore Deposit

The recent incorporation of the Natural Hard Metals Corp., of Beverly Hills, Calif., has revealed the discovery in the Little TaJunga mining district near Glendale of a rare ore producing a natural metal comparable in hardness with the highest-priced synthetic metals. For want of a permanent name, the new find is termed "X" metal. When four years ago the discoverers found a peculiar black ore and smelted it, they recovered a small amount of grayish metal which defies the use of the hardest files and emery wheels. Los Angeles mining experts tested the metal and found it harder than any known alloy. Announcement of the discovery was withheld while further experiments were carried on in Detroit, Toledo, and elsewhere. In tests continued for three years, it is said to have been proved beyond reasonable doubt that this "X" metal used as an alloy with nearly all existing metals promises to revolutionize certain lines of industry, owing to its extreme hardness and low cost of production as compared with synthetic alloys. The new metal is said to weld readily.

# Trade Literature

"Piping Tailored to Fit" is the title of a 26-page pamphlet issued by the Air Reduction Sales Co., 60 E. 42nd St., New York, N. Y. This booklet reviews the important advantages of oxyacetylene welding in the piping field and discusses in detail the economies in welded piping. Views of installations and drawings show the proper methods of design set-up for welding pipe connections. Comparative figures on weight and cost of threaded and welded installations are given.

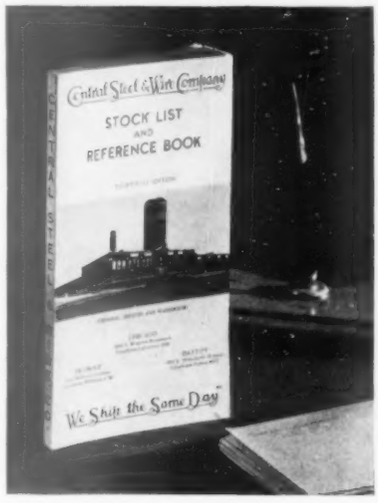
"What the Frameless Steel House Means to the Architect" is the title of Armco Architectural Bulletin No. 11, issued by The American Rolling Mill Co., Middletown, Ohio, which discusses the features of design and construction of the all-welded frameless house recently built in Solon, Ohio, and also describes briefly the house of similar construction to be erected at the Chicago World's Fair.

Fixed end connections, beams to columns, is the subject of Plate 39, "Studies in Structural Arc Welding," published by The Lincoln Electric Co., Cleveland, Ohio. Diagrams illustrate the various types of welds that can be employed, and examples are given for calculating weld strengths.

Enduro stainless alloys is the subject of a Bulletin 217-B recently issued by the Republic Steel Corp., Massillon, Ohio. A list of architectural uses of these alloys is given, and welding, soldering, brazing, and other methods of fabricating are described. Physical properties are tabulated, and diagrams show the methods employed for installing Enduro alloys on the Empire State and Chrysler buildings.

Sand blasting is featured in the January, 1933, issue of Fusion Facts, published by the Stoody Co., Whittier, Calif. "Arcing Along With W. F. Stoody" is continued in this issue, and "Dave Looks at 1933" describes an interesting rock-crusher repair job. Views are shown of a crusher bell and ring before and after being built up by welding.

Welding rods and wires, welding supplies, solder, structural shapes, steel tubing, and many other products are listed




General Catalog of Chicago Steel & Wire Co.

in a 254-page catalog issued by the Central Steel & Wire Co., 4545 S. Western Blvd., Chicago, Ill. S.A.E. specifications, tables of standard wire gages, and other reference material are included.

FlexArc welders of 300 and 400 amp. sizes are illustrated and their features of construction and control are described in two leaflets recently issued by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Welded all-steel gratings known as Plategrid and Floorgrid are described in a new catalog by the Truscon Steel Co., Youngstown, Ohio. Particular emphasis is laid on the light weight and high strength of these gratings.

"Austin Engineered Welding" is featured in a folder recently issued by the Welding Division of The Austin Co., 16112 Euclid Ave., Cleveland, Ohio. De-

scriptions are given of typical welded designs in which such features are pointed out as sales appeal, modern appearance, great rigidity, light weight, and economy.

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The features of "Republic" Electric Weld Pipe which make it particularly applicable as drive pipe and casing for water wells are discussed in a folder issued by the Republic Steel Corp., Youngstown, Ohio. Tensile and ductility tests of the weld material are illustrated.

Welding hose and many other types of mechanical rubber goods are listed in a 24-page illustrated catalog recently issued by The Diamond Rubber Co., Akron, Ohio.

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"Brazing With Low-Melting-Point Alloys" is the title of a reprint of an article appearing in the December, 1932, issue of *The Welding Engineer*. Copies are available from Handy & Harman, 82 Fulton St., New York, N. Y.

# News of the Industry

## Milwaukee School Has Heavy Enrollment

The second semester evening classes of the Milwaukee Vocational School recently started with both classes at about full capacity. One class meets on Monday and Thursday evenings from 7:30 to 9:30 and the other class on Tuesdays and Fridays. The instructor for the class meeting on Mondays and Thursdays is H. O. Quartz, welding foreman for the Allis-Chalmers Manufacturing Co. The other class is under the instruction of Geo. Hennis,, who is the regular welding instructor for the school and has charge of the day welding classes. The day classes are made up of high-school students, while the evening classes consist of mechanics, engineers, structural iron workers, and steamfitters who realize that welding is becoming a very important tool in their fields.

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## Dismantle Five Bridges With Torches

Four bridges over the Desplaines river in Joliet, Ill., have been dismantled by the Powers-Thompson Construction Co. of that city, and a fifth one is now being torn down. Oxyacetylene cutting torches are aiding effectively in this work. A dam in the Desplaines River at Joliet, a part of the Lakes-to-Gulf waterway, has raised the level of the river by many feet until now the water in some places was almost up to the old bridge superstructures. The new bridges will be at a higher level than the old and will be movable to allow boats to pass.

The five bridges are located respectively at Jackson St., Cass St., Jefferson St., McDonough St., and Ruby St., and they were dismantled in that order. All had a buckle-plate floor system with ballast and paving, which presented some serious problems in tearing up and cutting. The number and length of the spans are of interest, though all figures of length are only approximate. The Jackson St. structure had three spans of 90 ft. each and two of 75 ft. each. The Cass St. bridge had a 225-ft. truss span and a through plate-girder span of about 80 ft. The bridge at Jefferson St. had two truss spans of 125 ft. each and one through plate-girder span of 80 ft. Three truss spans of 125 ft. each constituted the McDonough St. bridge. The Ruby St. bridge, the last to be dismantled, has three truss spans of 115 ft. each. Other bridges along the river below the city will also be dismantled.

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## Blotters Feature Welding and Plating

A group of twenty distinctive blotters coated with a metallic foil is being designed by the Storts Welding Co., 44 S. Colony St., Meriden, Conn., for distribution to their cutomers and a mailing list

**One of Series of Blotters Used by the Storts Welding Co.**

of prospects. One of these, shown in the illustration is typical of the entire group. Although this blotter features the company's workmanship in lead welding, the blotters with the silvery foil will deal chiefly with chromium plating. The blotters colored in gold carry the message, "Mastership, the Gold in Welding Workmanship." J. D. Tierney, president of the company, states that the designs and idea are their own make-up. Seven of the 20 blotters have been completed, and these show an artistic sense of lay-out, type, and composition.

## Torchweld Elects New Officers

At the annual stockholders' meeting of the Torchweld Equipment Co., of Chicago, held on January 26th, the following officers were elected: C. K. Anderson, president; J. C. Kirchner, vice-president; C. F. Egbert, treasurer, and J. L. Jensen, secretary and general manager. The new officers, together with A. L. Beardsley, constitute the new board of directors.

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## Engineers' Day at Century of Progress

The program for Engineers' Day, June 28th, at the Century of Progress Exposition at Chicago includes an assembling of all engineers at the fair grounds at 9:30 p.m. After receiving the programs and badges, the assemblage will divide into groups and visit the scientific exhibits under competent guides. From 12 to 2 p.m., addresses will be given by prominent visiting scientists and engineers, following which the visiting of exhibits will be continued. In the evening, a banquet will be held in the Stevens Hotel, with accommodations for 2500 engineers, and, by means of loud speakers, an increased assemblage of 5000 will be able to hear the addresses.

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## Death of Augustine Davis

On January 19th occurred the death of Augustine Davis, at the age of 80 years. Mr. Davis' invention of an acetylene lighting generator won for him a gold medal at the St. Louis exposition in 1904. With Eugene Bournonville, he established the Davis-Bournonville Co. at Jersey City, N. J., to manufacture oxy-acetylene welding and cutting equipment. He also formed the Davis Acetylene Developing Co., the Davis Oxygen Co. and other firms. The first Morehead gold medal to be awarded by the International Acetylene Association was bestowed on him in 1927, at which time he was president of the Association.

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## Film Shows Manufacture and Welding of Wrought Iron

Five reels of motion-picture film under the title of "The New Story of the Ancient Red Ball," was shown by the A. M. Byers Co. at the Iowa State University welding conference, where it elicited much favorable comment. This film pictures vividly the manufacturing practices of a large mill and shows the manufacturing of pipe, sheet and plates from wrought iron. The welding of

# Repair-welded with TOBIN BRONZE

## *. . . this 1400 lb. casting is "as good as new"*

WHEN this huge pump casting froze and broke, a plate was bolted over the crack. Then the mechanical repair failed . . . and bronze welding was decided upon as the least expensive, quickest and best method of restoring the pump to service.

Preparation was completed by two men in two hours. Actual welding was accomplished by one man in six hours, 14 lbs. of Tobin Bronze and 140 cu. ft. each of oxygen and acetylene being required. The unusual nature of the casting necessitated pre-heating for about four hours, 5 gals. of distillate being used, although in ordinary work the low melting point of Tobin Bronze makes pre-heating unnecessary.

After welding was completed, the casting was covered with 10 lbs. of asbestos paper and allowed to cool slowly overnight. Then two men spent two hours each in testing for leaks with 65 lbs. water pressure, in grinding and finishing the weld. The casting was repainted and declared "as good as new".

The unvarying high quality of Anaconda Copper Alloy Rods is due to the technical experience gained in developing a complete line for low temperature welding —gas and electric. Anaconda Rods are available through leading distributors . . . usually shipped in bulk, but also obtainable in ten-pound packages. For complete information, ask for Publication B-13.

There is a suitable Anaconda Filler Rod for every bronze-welding purpose. Principal Anaconda Welding Rods, with their melting points, are listed below:

*for oxy-acetylene welding*

| | |
|---|---|
| Tobin Bronze* | 1625° F |
| Manganese Bronze | 1598° F |
| Brazing Metal | 1634° F |
| Electrolytic Copper | 1981° F |
| Silicon Copper | 1981° F |
| Phosphor Bronze | 1922° F |
| Everdur* | 1866° F |

*for arc welding*

| | |
|---|---|
| Silicon Copper | 1981° F |
| Phosphor Bronze | 1922° F |
| Everdur* | 1866° F |

*Reg. U. S. Pat. Off.

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# ANACONDA WELDING RODS

wrought-iron lap and butt welded pipe is also pictured. R. J. ("O-K") McKay, of the A. M. Byers Co., stated at the time the film was shown that wrought iron can be welded very readily, but that the technique is not quite the same as with steel pipe.

## Exhibitors at Iowa Welding Conference

The firms exhibiting welding and allied equipment at the welding conference held at the Iowa State College, Ames, Iowa, January 18th to 20th, were: Major Engineering Works, Des Moines, Iowa; Lincoln Electric Co., Cleveland, Ohio; Omaha Welding Co., Omaha, Nebr.; Air Reduction Sales Co., Bettendorf and Des Moines, Iowa; American Brass Co., Kenosha, Wis.; The Balbach Co., Omaha, Nebr.; Imperial Brass Manufacturing Co., Chicago, Ill.; The Linde Air Products Co.; General Electric Co., Chicago, Ill., and Smith Welding Equipment Co., Minneapolis, Minn.

## News in Brief

The Welding Equipment and Machinery Corp., of St. Louis, Mo., has moved to 3740 Washington Blvd. The company's former location was 4441 Manchester.

The Cadillac Machinery Co., 623 Fisher Building, Detroit, Mich., has been appointed exclusive dealer in the Detroit territory by the Bryant Machinery & Engineering Co., Chicago, for Imperial arc welders and several lines of machine tools.

W. E. Hooper, of the Aluminum Alloy Manufacturing Co., 714 Ensor St., Baltimore, Md., made two demonstrations for the students of the Cleveland School of Welding, Inc., of Cleveland, Ohio, on February 6th, using a metal which exhibited a high degree of ductility and tensile strength and which is applicable for use with aluminum castings at low temperatures.

W. H. ("Billy") Miller, after an absence of nearly a year on the Pacific coast, has returned to El Paso and the Southwest, and is now in charge of the sales and service department of the Modern Engineering Co., 1600 Texas St., El Paso, Texas. Mr. Miller introduced Meco equipment in this territory in 1924, and he has gained an enviable reputation as a service man.

## "Bright Spots" Selected at Random From Here and There

A recent severe wind storm in Southern California which wrecked something over 290 oil-well derricks created a vast amount of work for welders. Repairing of the rigs, oil flow lines, gas lines, oil separators, gas traps, pump houses, and various other repair jobs, have given much extra employment to welders and other oil-field workmen.

The Spokane (Wash.) Gas & Fuel Co. is planning the construction of 300 miles of welded gas pipeline to extend from the Cut Bank gas field in Montana to cities in eastern Washington. The estimated cost of the construction is about $12,500,000.

The Southwest Welding & Manufacturing Co., Alhambra, Calif., is fabricating two large all electrically welded steel tanks for the Los Angeles Soap Co. to be used for measuring and weighing liquids used in the manufacture of the soap company's products. These tanks will be elevated on a steel platform. Practically all the welding is being done at the soap company's plant on East First St.

Frank Hastings, of Peterson, Iowa, recently added to his welding equipment a new Smith welding torch, as well as a heavy-duty electric drill and a stationary drill.

Wm. F. Eichfeld & Son Co., of Milwaukee, Wis., recently bought a 200-amp. Lincoln welder.

Need for new and enlarged quarters and to incorporate newest practices has led LeRoy Randall, Clinton, Iowa, operating an electric and acetylene welding shop at 1621 N. Third St., to start construction of a new two-story place of business at 2215 N. Third St. which will be ready for occupancy by March 15. The new structure will be of brick composition, 30x40 ft., and has been especially designed to handle general acetylene welding work. Mr. Randall established his welding business in Clinton four years ago.

John Piesinger, blacksmith, of Fort Dodge, Iowa, recently added a new and complete Harris "Red Head" acetylene generator outfit to his shop.

Guy Stoner, Fort Dodge, Iowa, has added a Meco welding unit to his line of shop equipment.

Henry Baach, blacksmith, of Grand Island, Nebr., recently purchased a 125-amp. Hobart arc welder.

The Texas Co. is employing a considerable amount of welding at this time in its various natural-gasoline plants in Oklahoma and Kansas. Stabilizing units are in the process of erection at Atlanta, Kan., and at Pawhuska, Davenport and Kiefer, Okla. Much welding is employed in both the building of this equipment and in its installation.

P. H. Meyer, who operates a job welding shop at 939 Westmoreland, Waukegan, Ill., has devoted much of his spare time to building aquariums with welded frame work. Now his aquariums are being sold by leading dealers in the Middle West. The manufacture of these fish tanks led to the breeding of tropical fish, in which he has worked up a nice business. His job welding business, however, has not suffered, since he employs steadily a welding foreman and two welders.

The Tarkia Welding Co. has recently opened in Tarkia, Mo., with Miller and Stevens as partners. They recently purchased a 200-amp. gas-driven road-trailer-type Hobart arc welder from the Omaha Welding Co., Omaha, Nebr.

The Prima Co., Chicago, Ill., recently installed a 300-amp. gas-engine-driven General Electric arc welder.

The Fort Dodge Creamery Co., of Fort Dodge, Iowa, recently purchased a complete Harris welding outfit.

The Automatic Washer Co., Newton, Iowa, recently purchased a new welding outfit from the Newton Lock Co. of the same city.

The Welding Engineering Co., of Milwaukee, Wis., recently sold a 200-amp. Hansen gas-driven arc welder to Frank Tschury, of Mayville, Wis.

J. T. Gibbs, formerly welder for the Capitol Machine & Tool Co., Des Moines, Iowa, has opened a job welding shop in that city at 218 E. Walnut St.

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The Balbach Co., Omaha, Nebr., have been appointed distributors for the products of the Metallizing Co. of America, of Los Angeles.

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August Mortier, First St., Rock Island, Ill., has opened a boiler and welding shop in that city and has installed a 300-ampere Lincoln arc welder.

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The Major Engineering Works, 210 Jackson Ave., Des Moines, Iowa, have been appointed distributors in Iowa for the products of the Metal Spray Co., Los Angeles, Calif. The Major firm exhibited at the Iowa State College welding conference, with A. S. Miller in charge of their booth.

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The Alumaweld Co., of Glendale, Calif., a division of the Allied Research Laboratories, Inc., recently moved its offices from 710 E. Broadway, to 111 S. Glendale Ave.

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The Barnett Sheet Metal & Welding Works, of Bell, Calif., recently moved from 8417 Atlantic Blvd. to No. 7824 on the same boulevard.

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The completion of a new building at 735 San Fernando Road, Glendale, Calif., provides a new location for the Glendale Welding & Radiator Works. The shop equipment has been moved from the old location at 747 San Fernando Road into the new shop, which affords added convenience in addition to the other economical features. W. L. Heyn is owner and manager.

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W. J. Williams, of Huntington Park, Calif., has acquired the job welding shop at 6904 Pacific Blvd., formerly owned and operated by J. C. Dewey. Mr. Williams will do general welding work of all kinds, specializing in car starter-teeth welding. The shop, as in the past, will be operated under the name of the Dewey Welding Works. Mr. Dewey recently opened another shop in uptown Los Angeles at 237 S. Figueroa St.

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Burglars recently forced their way into the shop of the Electric Cutting & Welding Co., 7504 Atlantic Blvd. in Bell, Calif., and carried away a quantity of welding equipment such as torches, welding hoods, hose, etc. Mr. Underwood, owner of the shop, says that he is preparing to protect his shop against future offenses of this nature by installing a device which in case of a forceful entry will release a quantity of poison gas for the benefit of the intruder.

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The North Shore Boiler & Welding Co. recently opened at 1016 W. Washington St., Waukegan, Ill., under the partnership of Leonard Anderson and H. C. Bjork. The shop has bene equipped with oxyacetylene welding and cutting equipment and a portable gas-driven arc welder.

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The Balbach Co., Omaha, Nebr., are continuing this year their cooperation with the Vocational Training Department of the state of Nebraska, which is under the supervision of Sidney Owens. This cooperation consists of 60 hours of actual and practical welding training, and the courses of instruction are held in different towns and cities throughout the state. Omaha, Grand Island, Fairbury, and Hastings and other cities have availed themselves of this instruction.


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